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HOW LITTLE IVAN GOES TO SCHOOL– AND BIG IVAN TO COLLEGE

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Part I. Primary and Secondary Education

My neighbor Johnny Johnson starts to school when he is five years old, but his counterpart, little Ivan Ivanovitch who lives near Moscow, starts to school when he is seven years old. So do all the other children in the U.S.S.R. Johnny will develop his elementary and secondary education in 12 years, probably divided 6–3–3, and will very likely finish senior high school when he is 17 years old. Ivan will develop his elementary and secondary education in a system divided 4–3–3, ten years in all. His school will be free, coeducational, and compulsory through the seventh grade. He also will graduate when he is 17.

During this period his school will offer as much training as he can absorb. He goes to school six days a week, receives instruction thirty-three weeks a year, and is expected to do plenty of homework, which is prescribed as 1.5 hours a day in the second grade increasing to 3.5 hours a day in the seventh grade. His load is so heavy that the Soviet Government recently thought it necessary to decree that his teachers must not assign homework to be done on Sunday.

Elementary Grades

For the first four years he will wear a uniform, furnished by his parents, which will make him look exactly like all the other Ivans and will help him get the idea that education is a mass job controlled by the State and that he cannot expect much preferential treatment. In grades 1–4 inclusive, he will study Reading, Writing, Arithmetic, and Social Science as part of a curriculum designed and supervised closely by the State. The morning Ivan goes to class and is instructed in the art of long division, he gets as much comfort as possible from his sure knowledge that at the same hour on this same day of the week all the other Ivans in Russia in his grade will be studying long division.

For each of the first three grades, his teachers decide if he may go on to the next grade. At the end of his primary education in the fourth grade, however, he must pass an examination conducted and supervised by the State. There probably will be three examiners, one of whom will be his teacher, conducting both written

and oral tests for all the students in his class.

These examinations cover the whole year's work, and will be divided into about 50 parts. For the oral examination Ivan, along with the other children, will draw a card from a deck. Written on his card will be 2 or 3 questions which may relate to any part of the year's work. Ivan will have 30 minutes to develop the answers which he will give orally before his fellow students and the examiner.

Intermediate Grades

When Ivan enters the intermediate grades (5–7 inclusive), he must choose a foreign language, the study of which he will continue for six years. Here he will have some choice; this is the only elective he will have among all the subjects in his secondary education. English, the language of science, is probably the most popular. Homer and Norton Dodge, who in 1955 spent several weeks studying higher education in the Soviet Union, reported no difficulty in finding Russian students who could speak fluent and accurate English.

Now well grounded in reading and writing, Ivan will begin in earnest his solid educational program of background subjects. Besides a foreign language, beginning with the 5th grade he will also start the study of history, from ancient history to the history of Russia and the peoples of the U.S.S.R. in grades 9 and 10. An introduction to physical geography starts in grade 5 and continues to world economic geography in grade 10.

Biological sciences start as a survey of nature in grade 4 and continue through botany, zoology, human anatomy and physiology, principles of Darwinian theory and soviet genetics in grade 9. Physics starts in the 6th grade, chemistry in the 7th grade; mathematics is studied from the first day he enters school until he graduates. His study of algebra will start in the middle of the 5th grade. Before he finishes the 10th grade he will have studied plane and solid geometry, and trigonometry, with special emphasis on its applications to physics and engineering.

When Ivan is ready to appear before the examining board at the end of the 10th grade, among other things he has had are 6 years of history, 6 years of a foreign language, 5 years of physical and economic geography, 10 years of mathematics, including trigonometry, 5 years of natural science and biology, 4 years of chemistry, 5 years of physics, and 1 of astronomy.

From grades 5 to 10 inclusive, 47% of his instruction has been in science. Further, in a paper read before the UNESCO Institute for Education in Hamburg in late October of 1956, A. Shibanov, Head of the Department for Polytechnic Education in the Institute for Teaching Methods in the Pedagogic Academy, stated that the science content of the curriculum for the 8th, 9th, and 10th grades was being revised upward 15%.

Besides the basic work outlined above, Ivan also has had some extracurricular duties, required but not considered part of his basic course: singing, the absolute minimum of which is to learn by heart the hymn of the U.S.S.R.; drawing and introduction to technical drafting; physical culture and sports; military training in target practice, map reading, tactics, antiaircraft, and antichemical defense. In this extracurricular work grades are given but do not count toward graduation.

In his primary and secondary education, Ivan has had approximately 10,000 class hours of instruction. In Russia an instructional hour is 45 minutes. Putting this in terms of our own system and counting 25 class hours of instruction per week, Johnny Johnson also receives about 10,000 class hours of instruction by the time he graduates from high school. During his first ten years of education Ivan's average student-teacher ratio as of 1950 was 23.

This ratio has been steadily decreasing and as of 1955 is probably less than 20. During his ten school years in the grades, Ivan's report card carried the numbers one to five. These numbers were of great concern to Ivan's parents because they knew from long and bitter experience that education offers the main avenue for advancement to those who do not belong to the tiny minority holding party membership.

Ivan hoped the numbers would be 4's or 5's, for if he could maintain grades mostly of 5's he could graduate as a medalist. This means that he will have a better chance of passing the rigorous entrance examinations when it is time for him to go to college. A grade of one meant failure, while 2's and 3's meant that he might not be permitted to pass his grade. There always was summer school to which he could go to review his work and try another examination just before the beginning of the new school year. If he failed the second time he had to repeat the whole year's work.

Advanced Grades

Between the 7th and 8th grades is the first major break in the Russian school system, a break corresponding to ours between the 8th grade and high school. At the end of the 7th grade, Ivan's examinations are searching, for this is the terminal point for the low 10%—in our vernacular those whose IQ is 80 or less. After all, the educational system in the U.S.S.R. is set up to give the training a student can profitably use.

At this point all of the very best students are encouraged to stay in school, but some of the others will have an opportunity to leave the grade-school system and enter a technicum—a special type of middle-professional educational institution in Russia for which we have no counterpart. This will be described later.

Secondary School

In the Soviet equivalent to our high school—their grades 8, 9, 10—the student plays for keeps and the mortality is high. The prize to be won is the opportunity of going to college. Since the low 10% of the students have all been removed, the tempo of the program can be increased. All students through all three of these years study a foreign language, history, physics, chemistry, mathematics, in addition to several other subjects of one or two years in length. It is perhaps worth noting that syllabi and text books used in the last two grades (9 and 10) of the Soviet secondary school in such subjects as physics and chemistry compare favorably with our college introductory or freshman courses in these subjects. In addition to curricular instruction, the pupil's interest in science is further stimulated by all sorts of exracurricular activities, such as science clubs, hobby shops, and so on. All this makes for very early and intense exposure to science, which in turn creates very favorable conditions

for the future selection of higher education candidates in engineering and science fields.

In the United States, according to Dael Wolfle, Director of the Commission on Human Resources and Advanced Training in his report, *America's Resources of Specialized Talent,* Harper and Brothers, 1954, roughly 80% of our students enter high school and 60% graduate. In the U.S.S.R. about 80% enter the upper secondary school, but fewer than one-fourth of those who entered 10 years earlier succeed in passing the stiff state examination after the 10th grade.

If Ivan is really both bright and lucky and has studied hard enough to receive straight A's (that is, "5's") in all subjects, he will receive a gold medal. To do this he must stand in the upper 1% of those who graduate. If he has no more than three grades of B (4's), he will get a silver medal.

Many finish the three last years but fail the final examination. These students are given certificates in which they take great pride. The rest of the group is dropped at the end of the 8th or 9th year, though some of these find their way into technicums.

In 1956 there were about 28,000,000 students in the first 10 grades; 1,100,000 graduated. This indicates that the number attending grade school in the lower grades is increasing rapidly.

Part II. Colleges and Universities

There are 760 institutions of higher education in the U.S.S.R. that we would call colleges or universities, not counting any of the technicums. Thirty-three of these are full-fledged universities. In addition, there are 220 specialized institutes giving advanced-degree training.

The leading institution in Russia is the University of Moscow, which is housed on a new campus, in a huge recently finished building with a 33-story tower; next to the Kremlin, this is the most impressive structure in the city. Senator Wm. Benton reports the Russians spent three billion rubles on the new campus, "more than has been spent on any but a handful of American universities." Unlike our larger universities that may be fragmented into a dozen or more colleges, divisions and institutions, Soviet higher education is everywhere divided into five branches:

1. Engineering-Industrial
2. Agricultural
3. Socioeconomical
4. Education
5. Health

These five branches are in turn divided into a total of 24 fields, in turn subdivided into about 300 specialties. Not all of the collegiate institutions have all five branches, but whatever branches an institution has will be divided into the same fields and specialties as for other institutions.

To illustrate this, the Engineering-Industrial branch, as of 1953–54, was divided into 16 fields, as follows:

Geology and mining exploration
Exploitation of mineral deposits
Heat and electrical power
Metallurgy
Electrical and electronic design and manufacturing
Chemical Engineering

Machine building
Food technology
Wood processing
Light industry
Printing
Geodesy and cartography
Meteorology and hydrology
Civil Engineering
Transportation
Communications

With some minor exception in fields like Soviet Law, which is a four-year course, Soviet universities offer a five-year course with a major in science, based on 5200 to 5400 instruction hours of 45 minutes each. In general, such majors (as of 1952) have a time allocation of about 6% for political and social science, 27% for general science, and 67% for special field science. Although minor adjustments are frequently made, this arrangement has been relatively stable since 1938.

Political and social science subjects consist primarily of indoctrination in the present official version of Marxism; general science subjects include foreign languages, general physics, analytical geometry and calculus, biology, general inorganic chemistry, geology, theoretical and applied mechanics. The subjects in the first two groups are usually taken in the first two or 2½ years. Special field instruction occupies most of the last three years.

Let us specifically consider chemistry at the University of Moscow. Here Ivan as a chemistry major will receive about 2700 hours of instruction in chemistry alone. Two-thirds of this will be in basic inorganic, organic, analytical, and physical chemistry. In this basic work he will have on the average one hour of class work for each three hours of laboratory. In the one-third time spent on specialized courses, the ratio of class work to laboratory is smaller. In evaluating Ivan's training in college chemistry, it must be recalled that he had four years of chemistry before he came to college. Nicholas DeWitt of the Russian Research Center, Harvard University, states:

"If one compares the training of Soviet chemists with our own, one fact is immediately obvious. As far as instruction time is concerned, the Soviet university chemistry major spends at least one-third more time on chemistry subjects than our own chemistry major in a college with a good department of chemistry. At most, our college chemistry majors during four years of study take 10 full courses in chemistry with a probable maximum of some 2,100 instruction hours. As far as the range of subjects goes, there is no radical difference between those which may be, but often are not, elected by our own chemistry majors and those which are required of the Soviet student." . . .

"Even when we are admittedly optimistic concerning the scope and quality of our own training of undergraduate chemists, we are faced with the probability that Soviet training is not only comparable, but somewhat more extensive than our own, although as far as the teaching of certain selected topics is concerned there are undoubtedly various reservations. The sheer size of the workload, as well as the process of enforcing certain standards in grading and the number of examinations and tests, exercises considerably greater pressure on the Soviet university student majoring in science than it would upon our own college student. Furthermore, aside from the requirement to learn chemistry subjects proper, the Soviet student is required to learn more about other sciences, such as analytical geometry and calculus, physics, thermodynamics, me-

Moscow University Central Building. A thirty-three story skyscraper adapting in modern terms the traditional Russian architecture, the structure is typical of the provision which the U.S.S.R. is currently making for higher education. (Wide World Photo.)

chanics, strength of materials, etc., all of which are a part of his curriculum. . . . Our chemistry majors do not venture extensively into these subjects except at the expense of chemistry courses. This may perhaps be considered an additional element of strength in the Soviet training program."

DeWitt continues, saying:

"Soviet university training culminates in state-accrediting oral examinations conducted before a public audience, and given by a special committee of several professors set up for this purpose. The examinations cover the entire course of study in the field of the student's specialty . . . This procedure of requiring final examinations in public of all graduates who cover the entire program of study is unknown in our educational practice as concerns ordinary college degrees." [1]

The training of chemists analyzed briefly above suggests that the Soviet university chemistry major has training probably comparable to, or—with some reservations—somewhat more extensive than, our chemistry B.S. degree holder. The Soviet university-trained chemist from the larger universities such as Moscow, Leningrad, and Kiev is probably as well-trained as our master of science.

Engineering education in Russia follows, in general, the same organizational pattern as in science, except

[1] Nicholas DeWitt, *Soviet Professional Manpower* (Washington, D. C.: National Science Foundation, 1955), pp. 111–113.

that most science majors come from the universities while most engineers graduate from specialized institutes. The course is five and one-half years, during which time the student receives some 5200 to 5500 instruction hours of 45 minutes each in 35 to 40 individual subjects. This compares favorably with the 3700 to 4000 instruction hours and 22 to 25 subjects which is normal in U. S. practice. Each engineer has political indoctrination, physical training, and military instruction for about 15% of his total course work. The rest of the curriculum is in general about equally divided in three parts: (1) broad training in science, (2) general nonspecialized engineering, and (3) narrowly specialized engineering. The distribution of engineering students among the various branches is quite different from the distribution in the U. S., where electrical engineering constitutes the major group. In the Soviet Union mechanical engineers form the largest group.

Mechanical Engineering

Specifically, the mechanical engineering curriculum (based on the 1946 course of study, the latest complete one available for analysis) covers five years with 5054 instructional hours divided about 50–50 between lectures and laboratory practice. The general science background covers foreign language, mathematics, physics, chemistry, descriptive geometry, drawing, and theoretical mechanics. The engineering background consists of physical metallurgy, strength of materials, theory of machines and mechanisms, machine components, metallography, nomography, electrical engineering, fluid mechanics, tolerances and measurements, thermodynamics and heat-power engineering, and study-practice.

In the specialized engineering, Ivan studies lifting machines, machine tools (general), kinematics of machine tools, design and calculation of machine tools, technology of metal cutting, cutting tools, technology of machine building, welding, machine foundings, drives, cold stamping, structures and their design, machine-shop layout, electric equipment, automatic machine tools, heat treatment (tempering), organization of production, cost accounting and norms, and fire prevention and safety. A study of a recent Soviet engineering curriculum found in *Engineering*, February 10, 1956, a British publication, indicates that in the past ten years the curriculum has not been changed significantly.

Says DeWitt, (*Ibid.*, p. 121):

"If, for example, Soviet mechanical engineering training with narrow specialization in machine tools is compared with the Massachusetts Institute of Technology's bachelor of science degree in mechanical engineering training with a broad specialization in materials and material processing, it is found that Soviet institutes require about twice as many subjects and over 2,000 more hours of instruction time. In general, the scientific and engineering subjects taught at MIT are included in Soviet curricula. Most of these subjects cover nonspecialized engineering. Thus, broadly speaking, the range of general subjects in the two programs is quite comparable."

The American student of mechanical engineering probably spends more time studying general chemistry and physics than Ivan, probably mainly due to the fact that when Ivan entered college he had already studied 4 years of chemistry and 5 years of

physics. Judging from Soviet textbooks, there is no outstanding difference in material covered, although perhaps there is more extensive use of calculus in physics in the Soviet case.

Again, according to DeWitt,

"In higher mathematics the portion of the curriculum in mechanical engineering is substantially greater in the Soviet program (United States, 180; U.S.S.R., 340), perhaps covers the same ground as the American program. By the end of the second year, the Soviet student is expected to know analytical geometry, calculus, differential equations, elements of the theory of complex variables, and the fundamentals of vector analysis. Theoretical mechanics covers about the same ground in both programs, but again the time input is greater in Soviet training (United States, 135; U.S.S.R., 204). In theoretical and technical mechanics, the Soviet programs of instruction place greater emphasis upon graphic solutions than upon advanced mathematical statistics or operational calculus."

As in the United States, there is undoubtedly variation in the quality of engineering training in the Soviet Union. It is an axiom that the quality of training in any curriculum is dependent on factors such as the quality of the teaching staffs, training facilities and equipment, ability of students, and the process of selection. It should be noted in summary that the teaching staffs, as well as the equipment and facilities of Soviet engineering training establishments, are usually better than in other fields of Soviet professional education.

"The reason for this is that priorities are given to engineering establishments over other fields of study. As a rule, higher priorities are given to institutions training engineers for key industries, those directly related to armament production. Thus, institutes training aviation engineers, communication and electronics engineers, specialists in certain fields of mechanical, chemical, and civil engineering have not only more rigorous training programs, but also enjoy better student-teacher ratios, better facilities and equipment, and have better opportunities for selecting candidates. These inter-institutional differences account for the fact that there are some engineers with excellent training and some with inferior training. However, in spite of these variations, Soviet engineering training programs are in general substantially sound and are probably not inferior to our undergraduate engineering training."

Each engineer culminates his training with a diploma project which takes his full time from 4 to 6 months. During this time he does not take any courses.

"In most cases, the diploma project serves as a test of the student's ability to perform engineering calculations, to execute charts and technical drawings, and to apply existing norms and specifications, designed primarily for production engineers. Generally speaking, the Soviet engineering thesis, though consisting of engineering design and computations, is based primarily upon the use of already existing components, norms, and specifications. It therefore fits into one of the basic aims of Soviet engineering education, which is to train production engineers." (*Ibid.*, p. 125)

Narrow Specialization

One of the outstanding characteristics of Soviet engineering education is its intense training in narrow fields of specilization. One may view the excessive stress placed on narrow technological specialization as a hindrance to the development of creative scientific knowledge. On the whole, however, the development of Soviet

industry in the past 25 years has been based primarily not on original discoveries made within the Soviet Union but largely on discoveries, modifications, and adaptations, with occasional improvements upon models, types, and practices developed in social systems outside the Soviet Union by more advanced industrial technologies. Current Soviet Union engineering education seems well adapted to meet the needs of their present industrial development.

Since 1954 the Soviets have been continually introducing limited changes into their engineering programs which tend to reduce the narrow technological specialization and give more theoretical and experimental scientific and engineering courses.

One may wonder how Soviet higher education succeeds in giving more than 1000 instructional hours per year. Recently the government decreed that not more than 36 instructional hours might be given per week. About half of these require preparation of 2 to 3 hours each. Thus the work load of a science or engineering student is probably from 70 to 90 hours per week. It is a well-established tradition in Russian education to place a heavy burden on the student at every educational level. This burden is readily accepted because both Ivan and his parents know that education offers the one practical avenue for advancement.

At the end of each university semester, Ivan must stand stiff examinations, written or oral or both. The examinations are extensive in scope and the consequences for failure are harsh. By government decree he presently need not stand for more than 10 per year. If Ivan flunks a course he is put on probation which must be promptly removed. The process is rigorous, but it serves to select and motivate the able students and to enforce academic standards.

Before leaving the subject, it should be stated that when Ivan applies for entrance to a Soviet institution of higher education, he specifically identifies the area in which he proposes to specialize. This decision stands. On it Ivans sinks or swims. The Soviets have demonstrated no tolerance for students who would waste precious classroom space and teaching time by not being able to decide accurately and permanently what they wish to do. Under these conditions, out of 100 students who enter higher education, only about 60 succeed in graduating. In 1956 the colleges and universities in the U.S.S.R. graduated 250,000 survivors. Of this number, 71,000 were engineers.

Part III. Technicums—Semi-Professional Schools

Last May I had the privilege of addressing a group of engineers and scientists from one of the large military laboratories near Washington. In the discussion period afterward the most persistent question was, "How can we get some good competent assistants—some intelligent people who can help us and thus free our time so that it can be used at our higher levels of training?"

This problem has also plagued the Russians, except that they have done something about it by establishing Middle-Grade or Semi-Professional schools, called "Technicums," which

have no exact analog in our educational system. The Russians have about 3500 of these with a present enrollment (1956–1957) of about 1,900,000. These schools are operated, financed, and maintained by the various ministries in charge of the individual branches of the Soviet economy, but the curricula, text books, and instructional methods are controlled by the Ministry of Higher Education.

The Technicums are a kind of three-way cross between our "technical institutes," "trade schools," and our "on-the-job training programs." They hold a place of major importance in the Soviet program of higher education. These schools offer training in more than 1000 specialties that serve every phase of the Soviet society.

Students who have graduated from the 7th grade may apply for entrance into a technicum. If at least 75% of all Ivan's secondary grades are 5's and the remaining ones are all 4's, Ivan may enter without examination; otherwise, he must pass entrance examinations in three subjects. If Ivan enters from the 7th grade, as some 200,000 Ivans did in 1956, his course is sure to be four years in length.

There are still a few engineering technicums that can be entered from the 7th grade; however, they are rapidly being abandoned. Hence, if Ivan wishes to enter an engineering technicum, he should plan to finish all 10 of the secondary school grades, from which certain curricula require less than four years.

Let us specifically examine the curriculum in *mining engineering* at a Soviet technicum. It is four years in length with 6100 instruction hours, 27% of which are class work, 15% laboratory and computation, with 58% practical work. During the 4 years in this semi-professional training school Ivan studies:

General courses:

History of the U.S.S.R.
Russian language and literature
Mathematics
Physics
Chemistry
Foreign language

General technical courses:

Drawing
Technical mechanics
Electrotechnology
Machinery
Technology of metals

Special courses:

Geology
Mining
Geodesy and mine surveying
Mining machinery
Mine transportation
Mining mechanics
Mining electrotechnology
Fundamentals of enriching coal yield
Economics and organization of production
Calculation (cost accounting)
Rules for technical exploitation
Mine safety

plus some workship, field work, military training, and physical education.

Upon graduation from a technicum, the student is immediately assigned to a position for a period of three years, after which he presumably has somewhat more influence on the place and nature of the work he is to do from then on. The tremendous development of these semi-professional institutes in Russia is, of course, made possible by the tight state control of

the educational system. It is motivated by a desire to develop high technical capabilities in the less gifted individuals, thus increasing the effectiveness of the fully-trained professional worker.

In 1955, industrial technicums training technicians and supporting personnel for industry, construction, communication, and transportation graduated 122,000 students. Altogether, during the period 1951–55, Soviet industry, transportation, construction, and communication got 462,200 technicians and semi-professional supporting personnel from these technicums.

This fall the technicums are reported to have accepted 480,000 new students, of whom 60% were 10-year graduates of secondary schools.

Part IV. Graduate and Advanced-Degree Training

Soviet advanced degrees can be earned not only at the universities, but also at research institutes as well. Russia has a vast complex of research institutes and laboratories under the jurisdiction of the industrial ministries, the Academy of Science of the U.S.S.R., and the various republic academies. About 60% of the advanced degrees are awarded by the universities and about 40% by the various institutes. The degree of "Kandidat" corresponds closely to our Ph.D., and is awarded in 18 "fields of knowledge."

Training for this degree may be taken by individuals under 40 years of age who have completed their higher education and who can pass oral entrance examinations in (1) their specialized field, (2) one foreign language, and (3) in the principles of Soviet ideology. Training is organized on the industrial study plan. A ranking professor supervises the study of from two to five students. At the end of the first year, a dissertation must be selected, and at the end of the second year the candidate must pass a battery of qualifying examinations, including two foreign languages.

The entire third year is usually devoted entirely to work on the dissertation, which is publicly defended before the Academic Council of the sponsoring institution. If the defense is successful, the degree of "Kandidat" is awarded by the institution and confirmed by the Government.

Soviet sources state that a dissertation for a "Kandidat" degree should reveal general theoretical and special knowledge of the topic on which it was written. It should demonstrate the ability to perform independent research and present new scientific findings. These dissertations for an advanced degree are usually an integral part of a large, centrally-supervised program. These major efforts can be appraised only in terms of the general quality of Soviet work in a given area of science. Consequently, one would expect a wide variation in quality. However, there can be little question but that research in some branches of Russian science is advanced, extensive, and of good quality. In 1952 there were about 5500 "Kandidat" degrees granted, not substantially different from our own production of doctorates in the United States.

Part V. General Discussion and Summary

The present Russian Government has made it abundantly clear that it has a high regard for education as one of its most effective tools to be used in its drive for world domination. Although professing the aims of general education, the Soviet educational system in reality is uniquely geared for the training of specialized manpower. The individual must be educated, but the individual's education is to be used in making the State more powerful. The present Government has clearly indicated that it intends to furnish education to each individual in terms of his potentialities for contribution to the State.

Higher education is entirely tuition-free and *all* successful students receive monthly living-allowance stipends, which range from one-third to one-half of the prevailing average industrial wage. In addition, outstanding students receive bonuses. The stipends are differentiated in favor of engineering and science students. The Soviet wage structure also heavily favors scientific and engineering occupations, with wage ratios for these occupations ranging anywhere from two- to ten-fold above the prevailing average wage of other salaried workers and employees.

The Soviets operate by well-known five-year plans. At the beginning of the present plan, 1955–1960, ten grades of primary and secondary education were available to only 70% of the population. Their goal is to have such training universal by 1960. Their educational purpose is indicated by the intense teacher training program, and by the high percentage of college graduates turned back into teaching. At the present time this group is reported to be 50%.

The salary levels of teachers also indicate that the Soviets are playing for keeps. President Homer Dodge reports that the salary of an experienced upper-grade teacher is about the same as that of an experienced doctor, and three-fourths as much as that received by a factory foreman. The salary of a professor is four times that of a skilled mechanic. Furthermore, as of 1956, all tuition and fees have been removed for study at every level in higher education. Practically all students are supported by fellowships, the stipends of which depend upon the course of study, the level, and the quality of achievement to date. Thus by means of mass persuasion and bold incentives, the Soviet state makes every effort to channel the best available talent into engineering and scientific professions.

To enter a college or university, one must either be a gold medalist, a graduate from a technicum in the upper 10% of the class, or have passed searching entrance examinations. In engineering and scientific fields, for example, these examinations usually cover five subjects: physics, chemistry, mathematics, the Russian language, and a foreign language. These entrance examinations may be repeated as frequently as one wishes until one is 35 years old.

Because it is their only practical hope for advancement, probably no people in the world are so sold on education as those of the Soviet Union. That is why 56,000,000 of them

are presently engaged in some sort of educational enterprise for self-advancement and why the science reading room in the public library in Leningrad is full 24 hours a day, the night workers occupying it by day and the day workers by night. The Soviet Government is also sold on education. That is why it is spending more than 5% of the gross national product on education.

The slogan of the late master, Stalin, that cadres of specialists—their number, their quality and competence—will decide the outcome of the industrial build-up essential for communist victory, is now guiding his heirs more than ever before. Many scholars in the Western World have studied and made pronouncements upon Russian education, particularly as to the quality of their engineers.

It all adds up to the fact that the Soviet state by and large succeeds in attracting its ablest talent, and in channeling this talent where the State thinks it is most needed—in science and technology. The education of their enginers may be somewhat different from that of engineers in the Western World, but the quality seems to be at least substantially equal to that of our own products. In addition, the U.S.S.R. is presently training engineers at about *twice the numbers per year* that we are doing in the United States. Regardless of differences, we can ignore this combination of quality and quantity only at our own peril as a peace-loving nation. *Verbum sapiem!*

MOTION AND TIME STUDY COURSE

The Department of Industrial Engineering and the University College of Washington University in St. Louis will present from June 5 through June 14 a Motion and Time Study Intensive Course. This course, intended for personnel desiring a basic introduction to Motion and Time Study, will be given with the cooperation of the St. Louis chapters of the American Institute of Industrial Engineers and the Society for the Advancement of Management.

Material covered will be presented with emphasis on setting up correct methods before work is started, as well as on techniques for the improvement of existing methods and procedures. The objectives of the course will be to help prepare the attendee to apply Motion and Time Study to his own company, and to train other persons in basic techniques. For further information concerning course content, instructors, and registration, write to University College, Washington University, St. Louis 5, Missouri.

DO YOU KNOW . . . .

► . . . . That you shouldn't forget the Annual Meeting at Cornell on June 17–21? The Preliminary Program and housing, registration, and special events cards have been mailed, using the same addressograph plates as for the JOURNAL. If any member says he hasn't received a copy, find out if he is receiving the JOURNAL. If not, have him write us promptly to give us his current address so that we can get the records straight.

► . . . . That ASEE members on their way to or from the June meeting at Cornell University in Ithaca, N. Y., are most welcome to visit the Cornell Aeronautical Laboratory in Buffalo, N. Y.? An adjunct of Cornell University, the laboratory does research and development work in engineering and science, in aeronautics and related fields, to the amount of about $15,000,000 annually. It is located next to the Buffalo Airport, and is readily available for persons spending time between flights. There is much interesting research for those not holding a security clearance. Those who wish to see a particular project, however, should write in advance to establish appropriate clearance. These letters should be addressed to Mr. Ira G. Ross, Director, Cornell Aeronautical Laboratory, Inc., 4455 Genesee Street, Buffalo 21, N. Y.

► . . . . That travel routes serving Ithaca are:

Air . . . . . Mohawk Air Lines
Railroad . . . . . Lehigh Valley from New York, Philadelphia and Buffalo
Bus . . . . . Greyhound
Car . . . . . New York State Thruway. Use Exit 41 near Waterloo. Ithaca is 48 miles south on Route 96.

► . . . . That the summer programs on nuclear energy finally materialized? The contract between AEC and ASEE has been signed, and application blanks have been sent to the dean of each college of engineering having ECPD-accredited curricula. There will be a beginning or elementary course at Brookhaven National Laboratory and specialized or advanced courses for 25 or 30 faculty members at each of the following locations:

Argonne National Laboratory—Properties and operating Techniques for the Argonaut Reactor
General Electric Company, Hanford, Washington—Chemical Separation Processes (Previous "Q" clearance required)
Iowa State College—Metallurgy
Oak Ridge National Laboratory—Reactor Physics

All courses are for eight weeks except the one at Argonne, which is for 12 weeks. Just as last year, attendees will receive travel expenses and a stipend (up to $750) to match that paid the attendee by his institution. The advanced courses are open to those who attended the general course last summer and to others who have equivalent backgrounds. The cooperation of AEC in making possible this additional training of engineering teachers is greatly appreciated.

► . . . . That a report on "Objectives and Educational Programs In Nuclear Engineering Education" has been approved by the Atomic Energy Education Committee? Glenn Murphy of Iowa State is chairman of the special subcommittee making the

study, authorized by the Executive Board in November, 1955. Basis for the report is the marked impetus given the nuclear power field in 1955, and the developing new pressures on an already critical manpower situation. The report will provide information to institutions considering the education of students in the area of nuclear energy. Objectives, attainment of objectives, administrative methods, staff requirements, costs, and sources of assistance are included. It is hoped the report can be published in the JOURNAL and as a reprint costing about 25¢ per copy. Orders should be placed with the Secretary of the Society.

► . . . . That the Ethics Committee has completed its work on a revision of the "Code of Ethics of Interviewing Procedures"? It will be published under the title of "Recruiting Practices and Procedures" and will appear in the JOURNAL. Reprints will be available from the office of the Secretary for 25¢ each, or less for quantity orders. The need for revision arose at last year's Annual Meeting when the unethical procedures of some employers became generally known. The efforts of the Midwest College Placement Association in preparing an excellent initial draft are acknowledged. Responsibilities of the employers, the colleges, and the students are briefly stated.

► . . . . That the YET membership drive is beginning to show results? The total of new members is about 200 ahead of the number for the same date last year. But if a total of 1,000 new members is to be reached, the YET representatives who haven't done much up to now must get busy in a hurry! To those who have worked—congratulations and thanks; to the others, let's get going! The names of new members are published in the JOURNAL, but there is a time lag between preparation of lists and the dates of publication. In the future each list will bear a date in order to eliminate questions about who is or isn't listed.

► . . . . That at its mid-winter meeting the Drawing Division found Houston, Texas, to be a friendly city? One of the banks—opposite the plaza of the Shamrock-Hilton hotel—had on its huge illuminated sign—in letters about two feet high— "Welcome, American Society Electrical Engineers, Drafting Division." It caused many chuckles, but no decision was made as to who owed whom what apologies—except for the bank.

► . . . . That the 24th Annual Report of ECPD for 1956 is now available? Copies can be obtained from their office at 25–33 W. 39th Street, New York 18, N. Y., for $1.00 each. It contains committee reports, and of particular interest is the one by the Education and Accreditation Committee. Other contents are a three-page discussion of the Proposal for a Survey of the Engineering Profession, a list of accredited curricula leading to first degrees (by institutions and by curricula), and a list of accredited technical institute programs.

► . . . . That Circular 490 of the U. S. Department of Health, Education and Welfare, entitled *Enrollment, Teachers, and Schoolhousing,* contains some interesting statistics about elementary and secondary schools? The total enrollment in 1946 was 1.0 mil-

lion or 3.3 per cent more than for the previous year; the number of teachers increased 2.8 per cent in elementary schools and 9.9 per cent in secondary schools. Minimum requirements for the lowest standard teaching certificates vary greatly from state to state, but five states have a minimum requirement of less than two years of college for elementary teaching certificates, and for three states the minimum requirement is between two and three years of college for high school certificates. The number of full-time teachers holding emergency certificates amounts to 7.5 per cent of the total teaching staff.

► . . . . That the proposed revisions of the Constitution and By-Laws and the ballot for their adoption are in this issue? Most of the changes have been discussed for a year or more, and all have been approved by the three Councils of the Society—General, ECAC, and ECRC. Each amendment will be approved if at least two-thirds of the ballots returned within thirty (30) days after they are mailed are favorable. Tear out the ballot page, cast your vote, and mail to: Secretary, ASEE, University of Illinois, Urbana, Illinois.

W. Leighton Collins
Secretary

CORNELL INDUSTRIAL ENGINEERING SEMINARS

The Department of Industrial and Engineering Administration, Sibley School of Mechanical Engineering, Cornell University, has announced the Annual Industrial Engineering Seminars, June 11 through 14, 1957. These seminars provide an opportunity for critical study and reappraisal of some of the major problems of manufacturing planning and control.

A series of discussions will cover each of the following six areas: Industrial Management, Manufacturing Engineering, Small Plant Management, Methods Engineering, Applied Industrial Statistics, and Data Processing Systems. In addition, all participants attend several general sessions. Discussion leaders and speakers will be specialists from both industry and the Cornell staff.

The seminars will be of major interest to operating management personnel in line supervision and staff positions for industrial engineering, production engineering, cost accounting and cost reduction, production control, materials control, purchasing, data processing, and personnel administration. For additional information write to Andrew Schultz, Jr., Department of Industrial and Engineering Administration, Cornell University, Ithaca, New York.

1957 ASEE MEETING TO VISIT CORNELL'S NEW ENGINEERING QUADRANGLE

A. J. McNAIR

Publicity Chairman, 1957 Annual Meeting

ELEANOR BILLMYER

Assistant Director of Public Information, Cornell University

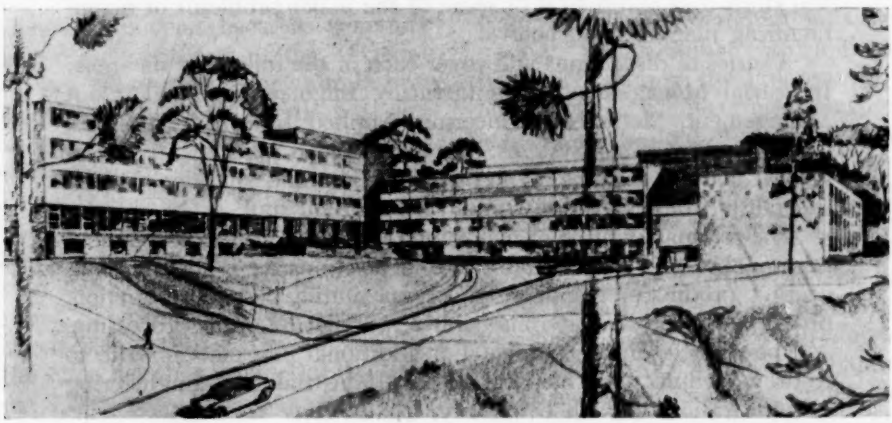
Sidewalk superintendents of the ASEE who come to Cornell for the June 1957 meetings can watch the growth of a new College of Engineering quadrangle, the product of 45 years' planning and work.

Each building offers the newest in teaching and research facilities, with special thought to space and equipment that Cornell's fifth-year engineering students need for their required research projects.

Four of the nine units are already in use, one will just be finished by June, and two will be under construction. Construction on the eighth will begin in the fall, and the ninth unit is in the planning stage.

Ground will be broken this spring for a new civil engineering building, a gift from Spencer T. Olin. One of its two wings will be devoted to laboratories, including a two-story space for hydraulics and sanitary engineering investigations.

To be done by autumn is Upson Hall for mechanical engineering, with laboratory facilities in thermal engineering, machine design, and industrial engineering. Attached to Upson Hall will be a building for the Graduate School of Aeronautical Engineering.



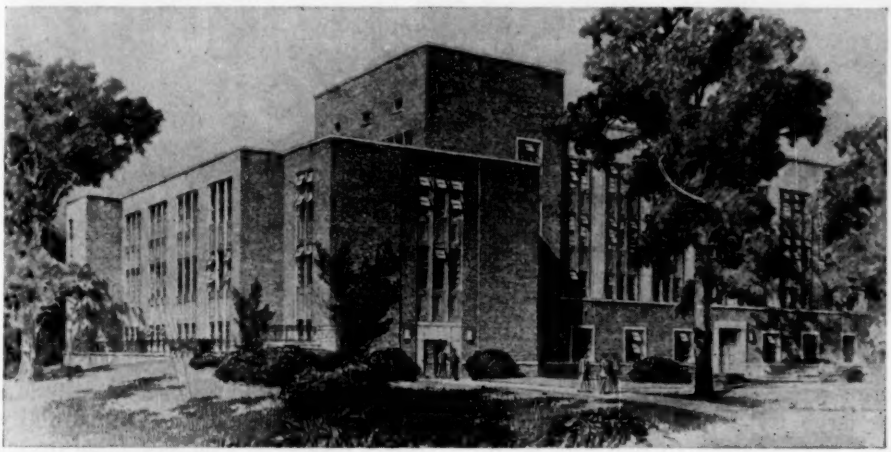
An architect's drawing of Cornell's new mechanical engineering building, Upson Hall.

A feature here will be a two-story wind tunnel and, beneath the first floor, a compressor and tank to provide air at a pressure of 3000 pounds per square inch.

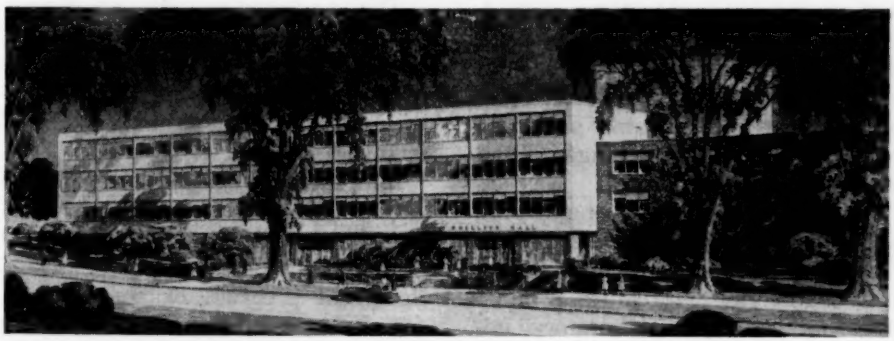
Carpenter Hall, housing the College of Engineering library and administrative offices, is scheduled for completion in May. The last of the nine units is to be a building for metallurgical engineering.

In Phillips Hall, the electrical engineering building, opened in 1955, are network calculator installations, laboratories for communications and vacuum tube studies, acoustics, power and machinery, servo-mechanisms, and the Cornell Computing Center, a service agency for the entire campus, with an IBM-650 installation. A flexible control board regulates power distribution as needed in various parts of this building.

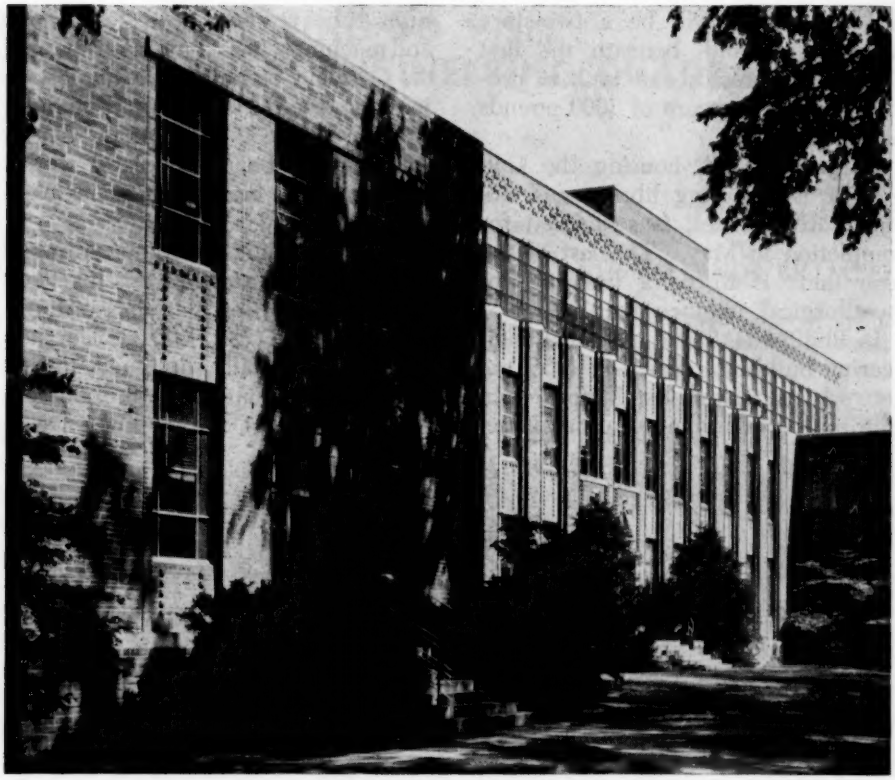
Two adjoining buildings—Kimball Hall, for materials processing, and Thurston Hall, for materials testing—were opened in 1951. Thurston houses a specially designed testing bay, 60 feet square and 50 high, constructed so that the building frame



Kimball Hall, left, Cornell's building for materials processing, and the adjoining Thurston Hall, for materials testing.



Architect's drawing of Phillips Hall, new Electrical Engineering building completed in 1955.



Olin Hall, housing the school of Chemical and Metallurgical Engineering.

forms part of the reaction mechanism for large tests. This structure, used with anchor wells to bed rock at intervals in the floor, permits simultaneous loading in several directions, as well as various combinations of loading patterns. Kimball Hall includes the mechanical engineering laboratories for machine tool studies, for plant layout and planning problems, production techniques, gaging, and time-and-motion studies.

The oldest of the new engineering buildings, completed in 1942, is Olin Hall, housing chemical and metallurgical engineering. It features a three-story unit operations laboratory, microscopy laboratory, rubber and plastics laboratory, and various metallurgical laboratories, including foundry sands research. Smaller laboratories for graduate and fifth-year students are located near the main facilities.

The engineering physics department is located in Rockefeller Hall, near the facilities of physics and the nuclear studies building. The electron microscopy laboratory is placed in this Hall.

Riley-Robb Hall for agricultural engineering is located on the upper campus of the College of Agriculture. It contains facilities for carrying on the three-fold program of teaching, research, and extension work. This building, which consists of a five-story

main unit and two-story laboratory wings, was completed in 1955.

Other facilities are located off the main campus for technical reasons. Typical are a high-voltage laboratory, radio astronomy and radio wave propagation laboratories, an ionosphere laboratory, and a high-head hydraulics laboratory, in the wall face of one of Cornell's gorges.

At Buffalo

ASEE members on their way to or from the June meetings at Cornell University in Ithaca, N. Y., are most welcome to visit the Cornell Aeronautical Laboratory in Buffalo, N. Y. The laboratory, an adjunct of Cornell, does research and development work in engineering and science, in aeronautics and related fields, to the amount of about $15,000,000 annually. The laboratory adjoins the Buffalo Airport, and so is readily available for persons spending time between flights.

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Riley-Robb Hall for Agricultural Engineering is located on the upper campus of the College of Agriculture.

TEACHING POSITION AVAILABLE

Staff openings in Civil, Electrical, and General Engineering; M.S. or Ph.D. desired. Salaries commensurate with qualifications. Write to School of Engineering, Tennessee Polytechnic Institute, Cookeville, Tennessee.

EMPATHY AND ENTROPY

W. L. EVERITT

President, ASEE
Dean, College of Engineering
University of Illinois, Urbana

Adapted from a discussion following the dinner of Young Engineering Teachers, on June 27, 1956, at the Annual Meeting, Ames, Iowa

The primary function of a teacher is that of communication—of ideas, principles, attitudes, and inspiration to the student (and perhaps to others). It has long been recognized that good educational practice must make use of psychological principles, and that a command of rhetorical, intellectual, or personal communication theory (whether conscious or intuitive) was an essential possession for the truly successful teacher.

Another formal area has been developed recently, however, in the field of engineering, an area not so obviously, but still equally, fertile and suggestive for teachers—the realm of what is commonly referred to as either Communication or Information Theory. Young engineering teachers might well consider the possibilities of combining these two kinds of communication, one social and emotional, the other physical or mathematical.

Our topic, of course draws one word from each, with the intent of applying them both to the problems we face as teachers. These problems include at least five or six major two-way interchanges of ideas and emotions, as shown by Figure 1: with students, with associates, with other members of the engineering profession, with administrators, whether educational or industrial, and behind these (as a matter of daily living), with our families, our community, and the larger public of citizens, newspapermen, legislators, and those we serve or by whom we are judged.

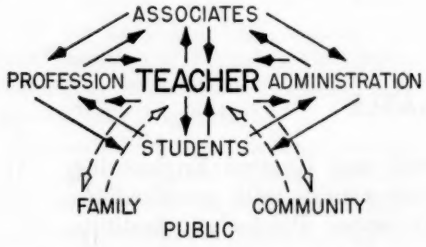

Fig. 1.—Communication Channels of Importance in Education.

The Terms of Our Problem

In relation to these briefly stated and reasonably obvious needs, let us look first at some definitions of our terms. Empathy is "mental, entering into the feeling or spirit of a person, appreciative perception or understanding; an imaginative projection of one's own consciousness into another being." This seems appropriate, and parts of it might apply especially to the teacher-student relation.

Entropy is not nearly so easy to define in verbal terms, largely because it is so generally described by mathematical equations. In a thermodynamic system, the usual context, total heat energy can be designated as Q, the temperature T, and entropy S, combined as $dS = dQ/T$. In terms of probabilities applied to phase states, the same entropy then becomes $S = \Sigma_j - p_j \log p_j$. In words, it may be

inferred that entropy is a measure of randomness, confusion, or lack of organization. Such a term can be applied not only in a thermodynamic sense, but also to information problems.

Entropy, then, is at a maximum when there is an absence of temperature gradient in a heat exchanger or complete mixing (as against separation) of two gases, or in an electronic message system when "noise" has relatively submerged any signal, either arbitrary or meaningful. In a negative sense, too, entropy measures the "unexpectedness" of a message, and this combination of significance is what makes the term so useful for communication theory.

It is readily apparent that unexpectedness, properly conceived, is inherently a characteristic of communication, whether in the classroom, the public press, or over a telephone system. If one gets a standard form greeting by telegraph on one's birthday (whether chanted or not) practically the only information received, regardless of words, is that someone has thought enough of you to spend a limited amount of money. If the greeting is from an enterprising business acquaintance known to possess an efficient secretary with a "tickler" file, the message may be even less significant. On the other hand, if the message (like Michael Anthony for John Beresford Tipton) says that you have been left a million dollars tax-free, this is information! Thus we measure value by unexpectedness!

Unexpectedness, or amount of information, has also been defined as the ratio of the probability of your knowledge of an event after the message is received to the probability before reception (or the *log to the base 2* of this ratio). For example, if a weather forecaster during July says it will be warm tomorrow, the unexpectedness and the information supplied are both low, but if he predicts *snow and cold* (assuming it will or does), the unexpectedness is high and the information spectacular.

It is interesting to note that Eddington, in his *Nature of the Physical World*, defines entropy in semi-psychological terms as we are doing:

> Suppose we were to arrange the following in two categories—distance, mass, electric force, entropy, beauty and melody. I think that there are the strongest grounds for placing entropy alongside beauty and melody, and not with the first three. Entropy is found only when the parts are viewed in close association and it is by viewing or hearing the parts in association that beauty and melody are discerned. All three are features of arrangement. It is a pregnant thought that one of these three associates should be able to figure as a commonplace quantity of science. The reason why this stranger can pass himself off among the aborigines of the physical world is that he is able to speak their language, *viz.*, the language of mathematics.

If this seems a shade difficult or obscure, you have just been formally and legitimately introduced to (a) entropy, and (b) Eddington. Perhaps I should only add that if we were to place empathy in this hierarchy or continuum of terms, it should fall just to the right of entropy, toward beauty and melody.

Application to Problems

Now that we have met our terms, how shall we apply them to our problems? Warren Weaver, of the Rockefeller Foundation, in a paper "Recent Contributions to the Mathematical Theory of Communication" suggests

that there are three levels of communication problems of all types:

(a) How accurately can the symbols of communication be transmitted? (The technical problem)
(b) How precisely can the transmitted symbols convey the desired meaning? (The semantic problem)
(c) How effectively does the received meaning affect conduct in the desired way? (The effectiveness problem)

Here I think we can develop an effective parallel between the block diagram of a standard communication system, for which you can supply the classroom, faculty-meeting, salary-conference, family budget discussion, or what you will, as shown by Figure 2. Note that the "pure" signal or wave begins to pick up noise from the random influences of the surrounding atmosphere and the materials of the network; as the signal is impressed on the carrier and transmitted, still other entropy-raising factors impinge, and by the time the signal reaches a badly-tuned receiver, the total effect is the usual result we expect in teaching a class on a warm spring day.

With meditation, this pattern may make you both more patient with students' failure to remember, or with Deans' refusal to be impressed by or appreciative of your most sterling efforts. It may also make you less patient with yourselves, for the clear implication is that high entropy levels require the application of still higher energy to the message. Also recommended is more careful circuit design or planning to avoid interference and insure closely-tuned, sympathetic receivers, or messages adapted to receiver characteristics—a case of empathy, I believe?

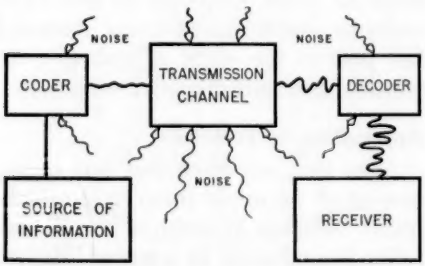

Fig. 2. Block Diagram of a Communication System.

Perhaps I should warn you that many major contributors to information theory protest very strongly against any application of their discipline in a qualitative sense. They feel that it should only be used when "Information" can be specified *quantitatively,* and fear that it will be confused with the word "Meaning," which is inherently semantic and qualitative.

As an extreme expression of this idea, I might quote from the Russian author V. V. Solodonikov, in his book, *Introduction to the Statistical Dynamics of Automatic Control Systems:*

Let us emphasize here that Soviet scientists approach the problem of using statistical methods in the theory of automatic control systems in a basically different manner than do the reactionary foreign scientists.

Soviet scientists use statistical methods for solving actual technical problems, which confront them in various fields of engineering and, especially, in automation, which has been called upon to play an important role in the movement toward communism in our country.

Reactionary foreign scientists, being captives of idealism and metaphysics, characterized by a professional narrow-mindedness and an inclination to claim as fact the fancy of their imagination, strive to use statistical methods and, es-

pecially the theory of statistical anticipation (extrapolation) for the creation of theories having nothing in common with science and which can be used only for sensations, for the creation of an untrue, absurd representation of the rate of development of technical progress.

Comparing man's brain to a complex calculating machine, and man himself to a combination of a large number of its controllable servomechanisms, they arrive at conclusions sounding recklessly to the Soviet man, that "man's brain, in the course of time, will become smaller and smaller," that "such a period will set in when machines will direct people," etc.

Indeed, "theories" of this kind would evoke indignation in the Soviet man. They only emphasize what degree of stagnation the modern capitalistic society has achieved.

On the contrary, I have found the general conclusions of quantitative information theory so startlingly illuminating in considering the Teacher-Student communication problem, I wish to list some of the important implications for you.

Ten Principles

To save your time and make all this a bit more specific, I would like to point out ten principles which have been developed by the engineering theory of communication, but which I will leave to your empathy for detailed application. I will try to suggest a few of the necessary corollaries to the basic statements, and you can set up direct parallels with the teaching situation.

Table I—Ten Important Principles in Communication Theory

A. "Amount of information" can be specified.
B. Uncertainty is mathematically analogous to entropy, and is measured in terms of probabilities.
C. In a communication system, each source has a maximum rate of producing information.
D. A communication system involves the principles of coding and decoding.
E. Coding and decoding methods must be compatible.
F. Each communication channel has a maximum capacity for transmission in symbols per unit time.
G. If the source rate exceeds the channel rate, errors at the receiver increase rapidly.
H. Noise increases the entropy or uncertainty at the receiver.
I. Redundancy reduces the entropy at the receiver.
J. Proper coding reduces the entropy at the receiver.

As an introduction, then, information must in general be translated into a code involving symbols and symbol sequences. This is done, for example, when your innermost thoughts are first translated into nerve impulses controlling your muscles, and are again translated into the code of audible or written speech.

In fact, any efficient coding system will use the shortest sequence of symbols for the most frequently occurring ideas, and longer sequences for less probable ones. A sophisticated or highly efficient code may, likewise, involve several stages or translations (like double crostics or T. S. Eliot's poetry of the objective correlative), requiring both a time delay to function and complexity in its design.

In this pattern, unexpectedness or a high level of information places the greatest strain on reception and decoding, just as the normal introduction noise introduces greater uncertainty. If we recognize this tendency in nature to increase entropy or relaxation (random expenditure of en-

(*Continued on page 715*)

THOUGHTS FROM ABROAD ON AMERICAN ENGINEERING EDUCATION

GEORGE S. EMMERSON

Senior Engineer
United Kingdom Atomic Energy Authority
Industrial Group Headquarters
Risley, Lancaster, England

A highlight of my introduction some years ago to Engineering Education in America was an interview I was granted with a departmental chairman in an important university. At a certain stage of the proceedings, the chairman raised a quizzical eyebrow as he glowered at me from the other side of his desk and snapped in his best executive manner: "What we look for in this university are: One, research ability—two, teaching ability—three, professional competence—four, public service."

I had the peculiar sensation of slipping farther down in my chair with each pronouncement, expecting all the while that my interviewer would bury his fist in the desk in one final cataclysm; but no, somehow sensing my confusion (or perhaps simply noticing that I slipped almost to the floor!) he continued in more comforting tones, "I'm explaining this to you because I know you come from England." (I came from Scotland.) At this, I daringly ventured the remark that it could hardly be said that the British altogether "rest on their oars," although it was true that in academic life they did not wield the "big stick." "Well," replied the chairman with a triumphant grin, "we sure wield the 'big stick' here!"

I am not going to claim that the manner of this interview was typical, or that the particular chairman or Dean concerned was altogether an ill-hearted fellow. This conversation has simply remained vivid in my mind as highlighting the dramatic contrast between the American attitude toward the teacher and teaching on the one hand, and the traditional usages of the universities and colleges of the Old World, on the other, or indeed, the usages of American institutions until comparatively recent times. I was soon to find that although the noblest motives of teaching as a calling were unquestioned, the teacher's desire to pursue that calling and his application to his work as mentor and scholar were not considered adequate in themselves. These had also to be proved in some other way. There was a clamor for obvious, external evidence, evidence that could be readily and frequently documented under one or other of the headings of approved activity favored by the college concerned.

Unfortunately, as most of us know, not all the laudable activities of the teacher lend themselves to documentation, and in the end it is published research work that generally determines the teacher's promotional future as a teacher. Even so, unless the research work is published it is virtually non-existent as far as administrations are concerned. Publication means success; to deserve success is not enough!

It has not been sufficiently observed that this policy discourages activity

on research projects, no matter how important, that show signs of slowness or special difficulty, and also that the main burden of the policy falls on the young engineering teacher who is under considerable pressure to prove himself. So many things clamor for his immediate attention if he intends to make a career of teaching!

Not only are there the onerous problems of teaching itself, of preparation and planning, but, there is also the need of widening his own knowledge—especially in the subject matter he is going to teach—and of his looking to the deficiencies of his cultural background and general education so neglected in the very nature of engineering. The catalogue does not stop there; he must take an interest in the progress of his students, in their activities, and in the activities of professional societies. It is in addition to all this that he must develop a research project which in the end will determine his future as a teacher.

Given time, perhaps all could be accomplished with reasonable success, but the young teacher is rarely allowed this time, and hence the paradox that if he is to justify his position as a teacher, it is precisely teaching that he must sacrifice. Is it any wonder, too, that many consider industry less demanding as well as materially more rewarding?

When I mentioned earlier that this state of affairs did not always exist, I had in mind a report by W. E. Wickenden, written in 1929, which states:

"There are still relatively few men of high research capabilities in our professional chairs; industry has requisitioned many of the most fertile for her own fast growing research establishment; and until quite recently there has been far greater incentive to textbook writing and to incidental practice than to research" (1).

The shoe is now on the other foot, and an increasing number of educators have been calling for a restoration of the balance between research and teaching. The work of the ASEE on the subject has culminated in two very excellent reports that leave very little more to be said (2, 3). The main difficulty remains, however, in the peculiarly American desire to evaluate the intangible and express it in numbers. Teaching is to be encouraged by "evaluating" it and rewarding it accordingly.

There is clearly a great difference of opinion as to how this is to be done. Hitherto, the emphasis has remained on encouraging staff to amass statistics of their activities, publications, meetings, and committees attended, and so on. Apart from the fact that this system does not "evaluate" a teacher's worth, much less as a teacher, it has the serious defects of putting a premium on cheap publicity and tending to profane honest endeavour with self-conscious self-advertisement.

Evaluating or Discerning

What, then, is to be done in this problem of encouraging "good" teaching? First, I think it will be agreed, any system of "incentives" which destroys a teacher's love of teaching, of self criticism, and honest scholarship, is undesirable in the extreme. Not all the methods suggested from time to time avoid these consequences.

One is tempted to ask if it cannot be accepted that teachers do achieve similar results in different ways. One resorts to gadgets and models as teaching aids, another to the power

of language and so on, each subject, too, demanding its own mode of treatment according to the caliber of the students being taught and the personality of the faculty member doing the teaching.

In fact, is it not true that, apart from the necessary knowledge and grasp of the subject matter, good teaching is basically a matter of personality? Certainly it can be claimed that the term "necessary knowledge" involves scholarship, but scholarship surely embraces more than simply experimental research. Is it not right to state that scholarship includes all essentially creative activities, such as the writing of books, articles, and papers, keeping up to date with developments in the sphere of interest, developing or devising course work, and indulging in cultural activities or eclectic studies that aid the creation of the complete man? The ASEE report (3) mentions most of them and the range is wide.

"This is all right and very well," you may say, "but surely we must then measure scholarship in order to give credit to the teacher?" Rather, "*discern*" scholarship, and I will agree with you. All systems of "evaluation" rest heavily on the judgment of our administrators, and I submit that if administrators know their staffs as they should, the various qualities mentioned previously which distinguished the "good" teacher can be easily discerned.

It only remains that administrators should be aware of the varied needs in a healthy engineering college, and the fertilizing force of varied skills or talents within a faculty. If one cares to look for it, the ASEE report again provides excellent guidance towards this end, although it does make more of "evaluating" or "measuring" than of "discerning," and of the insight that this latter word implies.

Class Visits

A method of "evaluating" teaching skill that has been advocated and practiced warrants special comment, namely, that senior faculty members visit the classes of the junior staff to assess teaching performance. It seems to the writer that this procedure has some serious and decidedly dangerous, perhaps harmful pitfalls. An alien, critical, and possibly hostile presence in the class is not only destructive of the teacher's morale but a real threat to his relationship with his students. The occasion may be very tense and little information can be gained that is of any value.

Certainly, if the senior faculty member is present to give helpful advice to the teacher, especially if he is present at the invitation of the teacher, the emotional circumstances might be different and good results might be expected. Still, there is much to be said for respecting the autonomy and privacy of the teacher in his own classroom.

Excessive zeal for evaluation should not be allowed to blind us to the great work that can be achieved by encouragement, a stimulating environment, and time to think and study. The greatest danger of this "evaluation" business, whether of teacher or student, is that it tends to become an end in itself, an all-devouring monster.

The Ph.D. and the Engineer

Another subject of concern is the academic qualification of the teacher. There has been a marked tendency in recent years for college authorities to

favour the Ph.D. as the basic academic prerequisite of teaching. This emphasis on paper qualifications seems strange in a country that has prided itself in the dictum "If you can do the job, it's yours!" It may be argued that, as the ASEE puts it, the Ph.D. "Demonstrates a background of integrated fundamental knowledge and probable creative ability in teaching and research" (3), but it would be invidious to claim the converse, that the absence of the Ph.D. demonstrates a corresponding lack of these qualities.

It can also be argued, no less vehemently, that although the chemist and physicist, for instance, may well regard the Ph.D. as the hallmark of his profession, it is just as important to the engineer that he should have rubbed shoulders with the practicing or "doing" side of his profession and measured himself against the decisions that are to be made in the design offices and in the industrial research and development establishments—decisions that dare not be wrong in terms of function, safety, and cost.

Indeed, until this experience is acquired, the engineering graduate is a very raw and unfinished product as also, of course, is the teacher of engineering who has never ventured from the cloistered atmosphere of school and college, whether he has a Ph.D. or not. If nothing else, it is a great advantage to both teacher and pupil that the teacher should have some first-hand experience of the kind of life his pupil is going to lead and for which preparation is being made.

To suggest that, in general, a student of engineering, whatever his attainment, should continue through school directly into the teaching of engineering without exposure to professional practice, is a serious mistake and seems to be implied in the following vague statement in the ASEE report (3):

> "If a student's interest is aroused in a teaching career, his study may be guided to embrace breadth of view and scholarly attitude."

Would it be too much to suggest that "breadth of view" and "scholarly attitude" be inculcated in all students, whether they are destined for teaching or not? It must be conceded, however, that these qualities are peculiarly indispensible to the teacher.

Oral and Written Communication

Unfortunately, "breadth of view" and "scholarly attitude" are not the only indispensables to the teacher, and it is difficult to find any other calling within the profession of Engineering that is so diversified and exacting in its demands. The realization, too, that we must counter the dehumanizing effects of our own industrial creation if our civilization is to prevail, compels us to restore the ancient union of the arts and sciences by emphasizing the importance of the humanities in engineering education, where indeed, as in the matter of oral and written communication, so much is left by the high schools to be accomplished at the college level.

Oral and written communication, however, are not a matter of culture alone, and a deficiency in either can be a real handicap to the professional engineer, a fact to which numerous employers will testify today (5). It is no surprise, therefore, that the ASEE report should emphasize the importance of "the teacher's own use of and insistence on the student's use

of clear English, both oral and written." Yet another requisite of the good teacher? It would seem so.

The deficiencies here are often traceable not simply to schooling, but to the poor standards of oral and written expression prevailing in our total environment. Much of the technical press, for instance, has prostituted its self-respect in this regard to the demands of advertising agencies. According to the so-called "readability" scales, of which a good discussion can be found in references (4) and (8), such writing makes a minimum demand on the intellect of the reader (to say nothing of the writer!). That can well be believed, but no one can say that such language conveys the idea behind it with anything like precision. Yet above all, the aim of technical writing should *be precision*, and precision cannot be achieved on a limited vocabulary.

Coupled with precision is simplicity, or better, clarity of expression. It is a mistake to consider that these ends will best be served by the arbitrary exclusion of words of three or more syllables. If a three-syllable word precisely expresses the idea, by all means use it! This is not the same as saying that if there is a choice of words the simplest and shortest should not be used.

Certainly the writer must consider the capabilities of his reader, but this does not excuse crudity and excessive "writing down" to readers of serious technical literature, and here I include students of engineering. If the language is not used, there will be no incentive to learn it. I think we should be very sceptical of the glib use of "readability" or "fog" indices, and very critical of the abuse of our language that sometimes masquerades as "simplicity."

As Professor Bolton states in his excellent article, "writing is not a science but an art." As with all arts, however, much can be learned from the work of those who are the masters of the art. It has rules and calls upon techniques that can be developed with practice and study; the rest, admittedly, is God-given.

In Retrospect

I have described a highlight of my introduction to Engineering Education in America and my initial reactions, albeit in a somewhat facetious vein.

What now, I have been asked, do I think of American engineering education after several years in its service and as one who has been intimately acquainted with engineering education in Great Britain both as student and teacher? Before I answer, it is well to remember that one cannot make a reasonable comparison of educational systems until the circumstances peculiar to each are fully appreciated.

Travel teaches us that there are often several excellent ways of accomplishing the same end, and it is the merit of such experience that one becomes more flexible and tolerant. Provincialism is anathema to education. There are, however, certain characteristics that stand unique and, first, I can do little better than quote again from Professor Wickenden's survey (1):

"American teachers of engineering merit a glowing tribute for their zeal in the study and improvement of the teaching process. Here the burden of world leadership clearly rests upon them, partly

because of the handicaps of preparation and preliminary selection under which they labor, but more largely because American education, more than that of any other country, centers in the individual welfare of the student."

This is so true today, that it is startling to realize it was written back in 1929. American education, it seems, is geared to the needs of the more moderate student. British education, on the other hand, at the university and technical institute level, has been adapted to the needs of the "top third," while the more average student along with many who have missed their opportunity, are comparatively neglected. Until the report of the British Productivity Council was widely consulted, it was about as difficult to convince a British educator that he could learn anything from America as *vice versa;* but the dawn is breaking. The British Government has recently appropriated funds to develop the necessary colleges and educational schemes to meet the needs of the times. At present, with the exception of the universities and the foremost technical colleges, which are notably well favored in this regard, too many British colleges are seriously understaffed, underequipped, and swamped with mediocrity, lacking the resources and the staff conditions of their counterparts in America that nourish the active interest and endeavor encountered there.

The teaching methods of the British universities and of the foremost technical colleges seem to be effective for the high class of student with which they are concerned, and since there is much reason to believe that, given a favorable environment and facilities for consultation, serious students will largely educate themselves, there seems no great incentive for the study of teaching problems as such. In fact, the optimum in the teaching of superior students would appear to be the "tutorial" system adopted in various forms by the leading British institutions. For a fuller treatment of some of the points raised here, as seen through the eyes of an American, the excellent paper by W. S. Rouverol (7) is recommended.

It is quite apparent that nowhere today is there to be found British interest in the problems of engineering education in any way as active as that evidenced in the U.S.A.; nor does a body truly comparable to the ASEE exist in Britain or elsewhere abroad. The nearest approach in Britain, so far, is to be found in the "Education Groups" of the professional institutions. Here, too, we touch on America's greatest strength—apart from material and human resources—the natural willingness of the majority of Americans to experiment, and their unique adaptability to change. Certainly, American teaching practice is not without its irritations, particularly where zeal degenerates into overzealousness, and one at times finds it difficult not to side with Wickenden when he declares (1):

"In nothing does the essential juvenility of our higher education reveal itself so fully as in the textbook, daily assignment, recitation, written quiz, piecemeal grading system of instruction, and in our eager effort to compensate for the student's defective mastery of the processes of learning by one and another pedagogic device. In the effort to make up for deficiencies of preparation, the indefinite aims of students, the lack of so-

cial and economic urges to educational achievement, as well as the absence of intellectual traditions in society and of standards of scientific competency in the technical professions, the engineering colleges of America have felt compelled to resort to a driving process. The student has less freedom and more routine than his European confrere. He probably does not work any harder, but he works under a different regime and under different urges. He is not an independent spirt striving for a large but distant goal and imposing on himself the discipline needed to attain it, he is too often a harried quantity producer trying to keep abreast of his quota of daily and weekly tasks."

But there is every encouragement to make progress, and every opportunity for the student. The provision for advanced study is extremely good, of course, and the rest of the world is taking notice!

A fundamental difference between the British and American college systems from which many other differences spring is the semester "unit" system. It is strange how this basic difference has been overlooked by visiting educators. The unit system gives the American student a great advantage over European ones.

By its means, he can take his degree in convenient installments, whereas the British undergraduate must attempt all the subjects of a particular stage simultaneously. Indeed, in many cases a failure in even one subject necessitates his taking the complete examination over again, including the subjects he has previously passed.

When one considers all the anomalies that can arise from this system, it is difficult to see how it can be justified. Other differences arise from the higher standard of British general education at the high school level and the importance attached to the craft apprenticeship in the basic training of engineers in Britain and Europe.

Among a number of differences in method, the most interesting is the assigned textbook and the "open book" examination or "quiz." The assigned textbook is usual practice in America. At its worst this can lead to the teacher's leaving the textbook to do the teaching and at its best it can save time, alleviate much drudgery, and encourage the student to develop a reference libarry. The "open book" examination (unless multiple references are used) eliminates the testing of pure memory, but places a premium on the knowledge of only *one* textbook (which of course, is better than none!) and on slickness of indexing that book for speedy reference. A textbook is best used as a teaching aid; examination questions can be set in such a form as will eliminate excessive emphasis on memory, and at the same time encourage the student to work from fundamentals.

In the matter of administration, it has been most refreshing to note how many deans, department heads, and professors meet the challenge of binding together the diversified personalities under their charge. An unhappy staff member is regarded by them as a criticism of their success as administrators, and it has been a revelation to the writer to discover how the most enlightened gives this problem special care and take their staff from the highest to the lowest into confidence, leading them as a team.

While it would be foolish to claim that all American administrators act in this happy way, more administrators of this type will be found in America than elsewhere. Of course, there are those who believe that an

administrator's success is to be measured in the number of memos he dashes off per day, or in how harshly he wields authority; but there are many more who believe that human insight is more valuable. It is reassuring that so many are coming to model themselves a little less on the apparent symbol of American success —the business executive—and a little more on the humanitarian and scholar.

Be all that as it may, there will be trends and counter-trends, and colleges can seek fame through the publications of their faculties as they will; but their most important product is still and always the student. It is on the quality of the human material they prepare for the world that our colleges must stand or fall. The American student is well cared for, with his advisors, vocational guidance, and the like.

If one would wish at times that he would discuss the humanities, ideas, politics, or world affairs a bit more, one must remember that he is not altogether to blame. It has been one of the writer's most rewarding experiences to have worked with him at many levels, and he has no greater admirer. If he goes into life ill-equipped to live it fully and ignorant of his great intellectual heritage, the responsibility to a very large extent will rest on his teachers.

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AIIE ANNUAL CONFERENCE

The American Institute of Industrial Engineers will hold its Eighth Annual Conference in New York City at the Hotel Statler on May 16–17, 1957. The Conference is open to anyone interested in management or industrial engineering.

More than 20 speakers will talk on topics including "New Techniques in Production Planning and Scheduling," "Incentives Pro and Con," "Design of a Management Reporting System," "Are We Going Overboard with Cost Figures?", "Inventory Control and Operations Research," and "Setting up an Industrial Engineering Program." Simultaneous sessions will be held which will allow those attending the Conference to be present at the sequence of talks closest to their special interest.

LIBERAL ARTS–ENGINEERING COURSES IN THE UNITED STATES

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Since World War II there has been a flourish of interest in the stratified liberal arts-engineering course. The stratification involves a separation of the liberal arts courses from the jurisdiction, as well as the confines, of the engineering school. It requires that such studies as the social-humanities, mathematics, and the *hard* sciences be completed in a liberal arts college before matriculation to the engineering school.

These courses are usually five-year affairs, but should not be confused with the five-year engineering courses offered at Minnesota, Ohio State, Cornell, and other institutions. At these places the curriculum is administered by the engineering school alone. Such curricula are categorically known as *stem* plans; the liberating studies are studied along with engineering courses throughout the five-year program. They represent another response of the engineering schools to the pressures for a broader engineering education.

Stratified Plans

The stratified plans are known in various parts of the country as the Combined Plan, the Binary Plan, the Three-and-Two Plan, the Professional Option, the Liberal Arts-Engineering Program. The first phase of the program, which is taken in a liberal arts college, usually requires three years; the final phase requires two years in an engineering school. It is usual that the bachelor of arts degree is given by the liberal arts college after the completion of four years of a five year plan. After the fifth and final year, a bachelor of science degree is awarded by the engineering school.

Variants

There are two variants of stratified plans—the off-campus and the on-campus. With the off-campus type, the liberal arts college and the engineering school are located in different institutions. It is this brand which is in minor vogue at present. It may be considered, with one possible exception, to be a post-World War II development. The MIT program is the exception. It began to establish "liaisons" with liberal arts colleges in 1936.

The on-campus variety is an historic type which attempts, within the bounds of a single institution, to provide a foundation of liberal education comparable with that for the so-called learned professions. There appear to have been two predominant influences in this development. One has been the inspiration of the French stratified system of engineering education. The other has been, and still is, the desire

for the recognition of engineering education as an unquestioned form of higher education and the correlative hope for the assured inclusion of engineering in the professional triumvirate of medicine, law, and the theology.

The increasing demand for engineers after the Civil War, however, stifled this development, which required a year or two more than the conventional four-year course. Toward the end of the past century a New York editor commented, "Let it be said that the pressure of American life is such that young men cannot be allowed to take the same time as their fathers for the training of character and acquirement of culture. . . ." In 1896, a president of the Society for the Promotion of Engineering Education reported to an annual meeting that "the tendencies which have existed toward a five year course have for the most part disappeared."

The post-war emergence of the off-campus variation of stratified undergraduate engineering education has seemed to some industrial, as well as academic, critics to be a promising response to their perennial criticism of the narrowness of engineering education. It is also a response to the desperate need for increasing the number of engineers. The fact that stratified plans tap a new source of engineering student has no doubt stimulated their growth.

The urgent need for increasing the number of engineering graduates, plus the fact that there has been nothing resembling an exodus from any one liberal arts college, has led also to the establishment of a satellite system of liberal arts colleges by a planetary engineering college. The table below shows the extent of these systems:

Engineering College	*Liberal Arts Affiliates*
Carnegie Tech.	23
Case	11
Columbia	43
Duke	5
Illinois Inst. Tech.	23
Lafayette	23
Maryland	1
Mass. Inst. Tech.	16
Michigan	7
Purdue	2
Rensselaer	13

It may mollify a liberal arts college graduate to know that his institution, too, may have its "stable" of engineering schools.

The number of students participating in this type of liberal arts-engineering course varies greatly. The most vigorous engineering college exploiter of this plan recruits about twenty per cent of its junior class from its satellites; another attracts ten per cent. But for most of the schools the program has not been in action long enough for such figures to be significant. The enthusiastic, however, consider the plan as worthwhile, and the prospects of increasing enrollments as good. Even the skeptical concede that the plan is in the "bears watching" stage.

The Columbia University School of Engineering, which has since 1914 practiced the stratified plan with its own liberal arts colleague, Columbia College, is a recent starter in the business of establishing a satellite group; its system is called the Combined Plan. Columbia seems, however, to be unrivalled in its vigorous development of the satellite system. In October, 1954, a three-day conference was held by the School of Engineering to discuss with its satellities the problems of the Combined Plan.

It was reported that over one hundred persons attended; included were thirteen college presidents, twenty-four deans, and forty professors. This was indeed an impressive representation of the liberal arts hierarchy. It may indicate to other engineering schools that liberal arts colleges are willing, perhaps even eager, to cooperate. Closer coordination between these important sectors of higher education, which have in the past tended to slight the values each could contribute to the other, is certainly to their mutual advantage.

Background of Stratification

The inspiration for the early stratified plans of engineering education, it was suggested, was the plan for national education in France which emerged after the French Revolution. This plan set up a system of lycees which provided a common classical education for all those intending to pursue professional studies. The lycee-engineering school sequence is analogous to our liberal arts-engineering plans. (It is interesting to note here that until 1852, the lycees made no accommodation in their curricula for the mathematics and science courses pre-requisite for entrance to their premier engineering school, the Ecole Polytechnic. After this date, however, a new arrangement called *Bifurcation* permitted those students interested in engineering to take these pre-requisite courses in the upper classes of the lycees.)

The first complete educational plan for engineering which stated its purpose to be education as well as training for a vocation was tried at Rensselaer Polytechnic Institute. It was a stratified plan following rather closely the French pattern. Developed by Prof. B. F. Greene, after he had visited and studied many European schools, it is described in his report, "The True Idea of a Polytechnic Institute" (1849). He wrote: "We may conveniently divide the instruction of the Polytechnic Institute into three parts: first the *Preparatory Course,* embracing all those studies necessary to matriculation in the institution; secondly, *the General Course,* constituting the foundation in general science and literature, on which, as a common basis, are erected the subsequent courses; and thirdly, the *Technical Courses,* which include all those special teachings, more or less peculiar to the objects of the institution."

"The idea behind the *General Course,*" wrote Prof. Greene, "is that of a system of disciplinary culture—scientific, literary, philosophic, artistic—prior to entrance upon the study of any form of applied science or art." The description of the *General Course* objective could be used for that of a lycee or a liberal arts college; the objective of the *Technical Course* was an attainment of engineering training in between that of the Ecole Centrale and the Ecole Polytechnic, the premier French engineering schools.

After this plan had been in operation for a few years, Prof. Greene noted again, ". . . in respect to a part—Literature and Philosophy—provisions for regular instruction have been made but the pressure of the more essential parts of the course has hitherto prevented the realization of these subjects." The pressures apparently continued, and by 1862 the stratified plan of Greene was telescoped into what became the prototype of the conventional engineering curriculum.

Though the stratified plan was gone at Rensselaer, it was not forgotten. In 1893 Director P. C. Ricketts of Rensselaer delivered this lament to a national meeting of the Society for the Promotion of Engineering Education: ". . . it may be said in general that the engineer is not liberally educated. Beyond his profession his knowledge is not great. The writer believes the statement that the average man in any of the other professions is better informed on non-professional subjects to be a true one . . . until the school of engineering is recognised as a post-graduate one, it can hardly be expected that the engineer will take rank among liberally educated men to which his professional work justly entitles him."

The interesting point about Director Ricketts' opinion of the 'other professions' was its comparatively recent validity. For some time before the Civil War, the professions of medicine and, particularly, of law had been undergoing a continual process of degradation from the high point of the Revolutionary War period. Many of the schools set up for training in these professions would accept students who could not obtain admission to any reputable college. It was the example of Harvard, in 1877, in requiring a bachelor's degree from a reputable college, or the demonstration of its equivalent, as a pre-requisite to admission to their Law School, which regained for the law the status of a learned profession.

In 1871, Dartmouth College, a liberal arts college, responded to the ideas of General Sylvanus Thayer, the "Father of West Point," concerning a stratified program for civil engineering education.

A classics scholar of the class of 1807, who left Dartmouth just before graduation, Thayer went to West Point for engineering training. He graduated from West Point in 1808. This was not an unusual situation—even in the early days of Rensselaer, a graduate of a classical college in the United States "well instructed in general mathematics and literature" could, after one or two semesters at Rensselaer, secure the degree of Civil Engineer.

The actual task of grafting an engineering school upon a liberal arts college required a person of considerable tact and will. General Thayer selected Robert Fletcher, a West Point graduate of 1868 who had been a classics student at CCNY, to work out his ideas.

The result was the establishment of the Thayer School of Civil Engineering as an associated unit of Dartmouth College. It was to be a two-year post-graduate course and to follow the four-year liberal arts course at Dartmouth, or its equivalent. The accomplishment in the College, which was held to be pre-requisite to admission to the Thayer School, was listed in a catalog of two hundred pages; the competency in mathematics and the sciences was to equal and perhaps exceed that required for graduation from the Ecole Polytechnic.

By 1893 Dartmouth College had raised its entrance requirements so that entrance to Thayer School could be accomplished in three years. The Thayer School program remained at two years. An A.B. degree was given by Dartmouth College at the end of four years of study; at the end of the fifth and final year, the degree of Civil Engineer was given by the Thayer School. In the fall of 1940 this plan was extended to cover a combined

business administration and engineering course; in 1945 mechanical and electrical engineering were included.

In 1896 Columbia University's engineering faculty recommended that a six-year stratified curriculum be established. Three to four years were to be spent in the liberal arts college, followed by two or three years of engineering study. A bachelor's degree and an engineering degree were to be awarded. But this program could not compete with the four-year program; not more than a few students selected the course despite faculty recommendation. This apparently did not discourage the faculty, which a few years later re-affirmed its faith in the six-year program.

In 1910 President Nicholas Murray Butler recommended that students should not enter the Schools of Applied Science directly from secondary schools but only after, at least, two years in Columbia College, the liberal arts college of the University. A four-year as well as a five-year stratified program was set up along the lines of President Butler's recommendations. In its latest catalog, Columbia's engineering school suggests, ". . . while this so-called five-year course is optional at Columbia, the school most strongly recommends this option to all students who can afford this additional year to the attainment of their first engineering degree."

The Future

Besides those of Columbia and Dartmouth, stratified programs have existed at other institutions but have not persisted. What their future development will be under greater concomitant pressures for increased engineering enrollments and steadily broadening educational concepts, remains an interesting venture to be observed further.

PENN STATE SUMMER SEMINARS

New developments in engineering will be presented at the Pennsylvania State University through eleven summer seminars. These include programs in Automation, Industrial Uses of Digital Computers, Electrical Contacts, and Nuclear Power Cycles, June 9–14; Creative Engineering, and Electrostatic Precipitation, June 16–21; Research and Development Management, July 7–12; Underwater Missile Engineering, July 7–19; Technical Report Writing, September 15–27; and Electric Utility Systems, one week in October. Enrollment is open to graduate engineers and scientists. Address inquiries to T. R. Ferguson, Extension Conference Center, The Pennsylvania State University, University Park.

SOME ASPECTS OF EINSTEIN'S RELATIVITY IN ENGINEERING EDUCATION

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Einstein's "theory of relativity" has been found indispensable to the physicist and to the astronomer in their studies on the motions of nuclear particles and celestial bodies. The engineer, however, analyzes the behavior of moving bodies on the basis of Newton's laws of motion and gravitation, without recourse to Einstein's relativity. What, then, is the relationship between Newton's laws and Einstein's theory, and how may this relationship bear upon engineering education?

To put it briefly, Newton's laws provide quantitative relationships that are nearly correct only when the velocities are much less than that of light, whereas Einstein's theory accurately accounts for the motions of bodies traveling at any velocity whatever. The physical concepts of Newton and Einstein are vastly different, in spite of the close agreement of quantitative relationships at ordinary velocities. Newton's laws, and his concepts, fail to account for or to agree with some clearly observed phenomena that Einstein's theory of relativity is able to explain. Thus, Newton's laws cannot be considered fundamentally correct. Rather, they should be considered to be highly useful approximations, based upon a remarkable but not entirely correct analysis by Newton.

Engineering educators pride themselves on emphasizing "fundamentals," as contrasted with empirical formulas or "how-to-do-it" methods. The situation of Newton's approximations versus Einstein's fundamental concepts is a case in point. Should the student be led to believe that Newton's laws are really correct, or should the true picture be presented to him? In nuclear physics, there is no choice, since Newton's laws are obviously and completely inadequate. However, what about undergraduate studies of the dynamics of rigid bodies? It is to this latter field that the present discussion will be principally confined.

For Students?

It is not the present writer's contention that the student of elementary dynamics should be burdened with the mathematical approach to relativity theory, though an introduction to some of the simpler concepts of relativity might provide an interesting incentive toward thought along truly fundamental lines. Some knowledge of relativity concepts on the part of the *instructor*, however, should contribute to his effectiveness in teaching engineering students about the dynamics of moving bodies.

If the aim of a course is merely teaching students to solve today's practical problems, relativity should be of little consequence either to the instructor or his students. But if our courses aim to train a student in the process of logical thinking, then

relativity provides excellent food for thought. Whether relativity is finally taught or not, at least Newton's laws should be presented for what they are, useful approximations of high numerical accuracy at ordinary velocities.

The present article will not undertake to offer any "thumbnail sketch" of the theory of relativity, but will endeavor to treat some of its more readily appreciated aspects. One of the theory's basic concepts is that "absolute" motion is meaningless, and that only relative motion is significant; hence the commonly used name for the theory. Some of the concepts involved in Einstein's theory of relativity are difficult to grasp, and require treatment by advanced mathematics such as tensor calculus.

Effective presentation of such concepts as the "curvature of space" would require treatment beyond the scope of the present article. However, it may be of interest to consider the practical example of a rotating disk, where the concepts of Newton and Einstein can be visualized and compared, and then to discuss some of the basic physical principles related to this example.

Examples

If we have a rotating horizontal disk with a radial groove, and if we place a ball in the groove at any radius, we find that the ball is thrown from the disk. Why? From Newton's laws, we deduce that a "centrifugal" inertia force acts on the ball to throw it from the disk, and that this centrifugal force is proportional to the radius times the angular velocity squared. What angular velocity is meant? The "absolute" angular velocity, of course, which is ordinarily taken to mean the angular velocity relative to the earth. But is not the earth turning too, relative to the sun? Furthermore, the sun is moving relative to the other stars in our galaxy, and our galaxy is moving relative to the more distant stars. Even the distant stars are known to be moving relative to each other.

What, then, can we take as a truly stationary reference in determining the "absolute" angular velocity of our rotating disk? Newton thought that some extremely distant bodies might be truly motionless. Others have thought that "space" itself might be motionless, i.e., that there might be a stationary massless medium (termed "the ether") pervading the universe. However, experiments conducted on earth or elsewhere are fundamentally unable to determine whether anything is really motionless or not, since only the motion of one body relative to others is capable of detection. All experiments to detect the motion of the earth relative to any stationary "ether" have had negative results.

It thus appears that we have no stationary reference upon which to base our determination of absolute motion. Since all we can determine is the motion of one body relative to others, why is it not justifiable to assume that our rotating disk is actually stationary, and that the rest of the universe is revolving around it, rather than to assume the disk itself is rotating? The answer must be that it *is* justifiable, and that the ball must be thrown from the disk in the same manner whether the disk is rotating, or whether the universe is rotating around the stationary disk.

A truly fundamental study shows that it is only the *relative* motion that can be significant, since absolute mo-

tion is indeterminate and meaningless in the absence of any stationary reference. Einstein recognized this situation, and it is covered in his theory of relativity, in which he has stated the following: "All bodies of reference are equivalent for the description of natural phenomena, whatever may be their state of motion."

But if the "rotating" disk is to be considered stationary, then why should the ball be thrown from it? Newton's laws offer no suggestion in this respect. Einstein, however, has shown that when there is angular motion of the disk relative to the rest of the bodies of the universe, the gravitational effects of those bodies on the ball are exactly the same as the effects that Newton attributed to centrifugal inertia force.

Centrifugal force on the ball, fundamentally, is thus only a "convenient fiction" (and the same is true of the Coriolis force), and the theory of relativity makes unnecessary the concepts of centrifugal and Coriolis forces. If the disk, with the ball resting on it, were surrounded with a rotating solid ring, the ball would tend to be thrown from the disk just as if the disk were rotating, but the gravitational effect of any practicable rotating ring would actually be too slight to move the ball against friction.

The distant celestial bodies may seem to be too far off to have important effects on earth, but their tremendous total mass is sufficient to cause the observed phenomena by gravitational action, and this has been demonstrated mathematically. If the disk and ball were the only objects in the universe, rotation of the disk would not throw off the ball. There would indeed be no way to tell that the disk was rotating at all.

The foregoing discussion of the rotating disk involves a number of basic principles whose expression depends on the meanings of such terms as "gravitation," "inertia force," and "relative motion." Let us examine these familiar terms briefly.

Gravitation

The engineer generally thinks of gravitation as the mutual attraction between any two bodies. But how can one body exert a force on another, when they are separated by empty space? This "action-at-a-distance" was puzzling to Newton, as it still is to most persons. Einstein explained the situation by introducing the concept that each body creates a gravitational "field" around itself, of indefinite extent, much like the magnetic and electrostatic fields that are taken up in elementary physics.

The gravitational field of any given body acts upon any other body, tending to cause the bodies to move toward each other, but fundamentally this need not be considered the action of one body "attracting" the other body. A crude analogy may help to indicate the nature of this action of a gravitational field.

Suppose we stretch a sheet of rubber horizontally, like a drumhead, and place a small marble anywhere on it. Then if we place a heavy ball on the sheet of rubber, we observe that the marble immediately moves to the heavy ball. Is this because the heavy ball "attracts" the marble? No. The heavy ball causes the rubber sheet to assume a form such that the marble moves to the heavy ball. The distortion of the rubber sheet, caused by the heavy ball, is somewhat analogous to a gravitational field (which

the relativist visualizes as a "curvature of space").

The gravitational fields of any two bodies often have nearly (but *not exactly*) the same effects as would attractive forces about proportional to the product of properties of the bodies known as their "gravitational masses," and inversely proportional to the square of the distance between them. The theory of relativity shows, however, that gravitational effects between two bodies are different when the bodies are in motion relative to one another. In the case of the ball on the rotating disk, relativity shows that the gravitational fields of distant bodies should produce exactly the effects that we commonly ascribe to centrifugal and Coriolis forces.

Inertia Force

Newton found that a force acting on a body produces an acceleration inversely proportional to a property of the body that is now referred to as its "inertial mass." The reaction to the applied force has become known as the "inertia force." Newton noted that the gravitational mass and the inertial mass of any given body appeared to be identical, but he could not deduce any reason for this other than happenstance.

Einstein showed, however, that gravitation and inertia are fundamentally equivalent (Einstein's "principle of equivalence"), so that a body's gravitational mass and inertial mass *must* be identical. To illustrate this equivalence, consider an elevator that is first at rest on the earth, and that is later removed far from any other body and is then moved in its vertical direction with an acceleration equal to "g." A person in the elevator would be unable to distinguish the gravitational situation from the inertial situation, and any experiments that he might perform within the elevator would appear identical in the two situations.

Thus inertia force in general, like the centrifugal force on the ball on the rotating disk, is not anything fundamentally distinct from gravitation. The elevator accelerating in space could just as well be considered to be stationary, with the rest of the universe accelerating relative to it, and then the phenomena occurring within the elevator would have to be considered to be the effects of gravitational fields of distant bodies.

Relative Motion of Two Points

In elementary kinematics, we say that the velocity of one point relative to another is the vector difference between their absolute velocities. The foregoing discussion has noted, however, that absolute motion is really meaningless, since we have no known stationary reference. In the absence of a truly stationary reference, we ordinarily consider "absolute" motion to mean motion relative to the earth, but this is not basically a sound concept.

On our previously mentioned rotating disk, we say that a point at a certain radius is moving tangentially with a certain velocity relative to the center, and thereby has an acceleration relative to the center and directed toward it. But if the disk can be assumed to be stationary, with the rest of the universe revolving around it, then all points on the disk are stationary and have *no* velocity or acceleration relative to the center. Thus, our usual concepts of relative velocity and relative acceleration are open to

serious question concerning their fundamental validity.

If the distance between two points is changing with time, then one point has a definite velocity component relative to the other point, along the line joining them, no matter how we view the situation. Also, the rate of change of this relative velocity is a definite value of relative acceleration. However, the motion of one point relative to the other, *perpendicular* to the line joining them, is fundamentally meaningless unless we introduce a reference body such as the earth.

If we choose a reference body *other* than the earth, then the velocity of the one point relative to the other point will be different from its value when the earth is the reference body. Fortunately, for practical engineering purposes, we obtain sufficiently correct answers by assuming motion relative to the earth to be absolute motion. From the standpoint of fundamental understanding, however, it seems that this fallacy should not be overlooked even though it may be safely neglected under ordinary engineering conditions.

Variation of Mass with Velocity

Newton believed that the mass of a body was an inherent property of it, independent of the motion of the body. It has been found experimentally, however, that the mass of a body appears to increase with its velocity, and appears to approach infinity as the velocity approaches the speed of light.

This mass increase is unmeasurable at the velocities acquired by bodies of appreciable size, but particles such as protons and electrons have been accelerated to such high velocities that their masses have been thereby greatly increased. Electrons have reached 99.99999 per cent of the speed of light, with around a thousand-fold increase of mass. Successful particle-accelerators, such as cyclotrons and other "trons," could not be designed without taking into account the increase of mass with velocity. Relativity theory accurately predicts this dependence of mass upon velocity, which should be equally true for bodies of any size traveling at any velocity.

The variation of mass with velocity has a fundamental bearing on the well-known engineering relationship that "force equals mass times acceleration and is in the same direction as the acceleration." Actually, Newton said that "force equals rate of change of momentum" (or at least that is the usual translation of Newton's Latin statement of his law). If we accept the definition that momentum is the product of mass times velocity, we can include the variation of mass with velocity, and solve for the force that would produce any given acceleration of a body at any given speed.

Such an analysis shows that the accelerating force would have to be made up of two components, one of which is equal to the mass times acceleration and is in the direction of the acceleration, and the other of which (a function of the velocity) is in the direction of the *velocity*. This second component is negligible at ordinary velocities, but becomes significant at velocities approaching that of light. Thus our highly useful and usually highly accurate expression of $F = ma$ is another supposedly fundamental relationship that is in fact only an approximation of the true situation.

It might here be mentioned, however, at the risk of unduly complicating the discussion, that if the observer were to move along with the high-speed particle in an accelerator, the mass of the particle would then appear to remain constant. The apparent increase in mass is a "relativistic" phenomenon, but it nonetheless is a real phenomenon that the nuclear physicist and his instrument designers must take accurately into account.

Further discussion here of relativity and its concepts will be limited to the brief enumeration of some additional aspects that may be of interest to engineers, but whose detailed treatment is beyond the scope of the present article. Among these concepts are three that Einstein developed and that have been verified experimentally.

The Precession of Mercury's Orbit

Newton's laws imply that the orbit of a planet around the sun should be an ellipse whose orientation remains fixed, relative to the stars (except as influenced by other planets). Einstein's modified law of gravitation showed that the orbits should slowly revolve or "precess," and specifically that Mercury's orbit should precess at the rate of 43 seconds of angle per century (in addition to precession causes by other planets). Astronomers have found Mercury's precession to check Einstein's figures accurately.

Miscellaneous Topics

Gravitational Deflection of Light. Einstein predicted that gravitation should deflect light, and specifically that starlight grazing the sun should be deflected by an angle of 1.75 seconds. Astronomers' observations taken during eclipses have shown this prediction to be accurate.

Gravitational Effect on the Frequency of Light Waves. Einstein predicted that the gravitation of very dense stars should cause their light to have slightly lower frequency, as measured on earth, than similar light from less dense stars. This prediction has also been found to be correct. Einstein stated that if any of these three predictions had been found wrong, his theory of relativity would have thereby been basically disproven.

Maximum Attainable Velocity. Since the mass of a body appears to approach infinity as the velocity of the body approaches the speed of light, it follows that no body can equal or exceed the speed of light, relative to any other body. If two bodies are approaching each other, each at a speed (relative to the earth) nearly equal to that of light, their velocity relative to each other is still slightly below that of light.

Their relative velocity can be readily computed with a simple expression that involves the ratio of the speed of light to the product of their individual velocities relative to the earth. Thus, our common concept in engineering kinematics that "the relative velocity of two bodies is the vector difference of their absolute velocities" is in fact only another approximation that is highly accurate at ordinary velocities.

Constancy of the Velocity of Light. Relativity theory states that the velocity of light relative to any given body is the same, regardless of the velocity of that body relative to the source of the light (except that it is affected somewhat by gravitation).

Mass versus Energy. Relativity implies that there is no clear distinction between mass and energy, so that the

old laws of conservation of mass and of energy, separately, must be combined into a single law of conservation of mass and energy together. A relationship between mass and energy is given by Einstein's equation that $E = mc^2$, where E is energy, m is mass, and c is the velocity of light. This relationship is importantly involved in nuclear reactions where the total mass before and after the reaction is different, and energy is given off or absorbed, as in the generation of nuclear power or the explosion of a nuclear bomb. It is also involved in the variation of mass with velocity, and in the deflection of light by gravitational fields.

Distance versus Time. Relativity also implies that there is no clear distinction between distance and time. The universe is presumed to be a four-dimensional "continuum." However, the four dimensions locating a point in the universe are not simply three distances and time, separately, but rather they are four dimensions each of which involves something of both distance and time. Relativity shows that the distance between any two points is not an absolute quantity, but that it varies with the velocity of the observer relative to the two points being considered.

Simultaneity. Relativity implies that it is impossible to determine whether any two events in different locations occurred simultaneously or not; and that observers in motion relative to each other may reach opposite conclusions as to which event occurred first, even after taking the travel time of light into account. Simultaneity, like absolute motion, is thus found to be not only indeterminate but meaningless.

The Universe. Relativity implies that the universe is finite in size, but is unbounded. Perhaps the best analogy is the observation that the surface of a sphere is finite in area but is unbounded, but it is not easy to extrapolate this analogy to our presumably four-dimensional universe. Relativity states that geometrical relationships in space do not follow Euclidean geometry. For example, the sum of the angles of a triangle in space is more than 180 degrees, as in the case of a triangle drawn on a spherical surface. From the standpoint of non-Euclidean geometry, light appears to have infinite velocity, which fact relates to its having the same velocity relative to any body that it strikes.

There are various other concepts developed through Einstein's theory of relativity, that should be of great interest to the thoughtful student of that theory, but those taken up here were chosen as being of particular interest to a person of engineering background. The interested engineer can find a great deal of pertinent literature on relativity, treated either descriptively or mathematically, as his preferences may dictate. Einstein himself has written some excellent nonmathematical discourses on relativity, as well as his outstanding technical presentations. The present writer has particularly enjoyed the popular but accurate dissertations of Gamow and of Lieber on the subject of relativity. These and other references of the present writer's choice appear in the attached bibliography.

It is to be noted that whereas the present article refers only to Newton and Einstein by name, the efforts of many scientists have contributed to the sciences of classical dynamics and of relativity, and that these two men

represent only two leading geniuses among others of comparable accomplishments.

It may be appropriate to close with a quotation attributed to Einstein, that "common sense is only an accumulation of prejudices acquired prior to age eighteen," and to note that this sentiment might be well taken by the engineer confronted with the technical problems of today and tomorrow.

Any engineering educator not already familiar with "relativity" should profit from a little study of that theory, its implications, and its experimental verifications. He will find his thinking processes stimulated and his mental horizons broadened. He will learn of verified phenomena that contradict his "common sense." He may find that some of the "fundamental" physical relationships that he teaches are in fact only good approximations. As a result of a broadened outlook on physical phenomena, he should become a better teacher.

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CORNELL ANNUAL HIGHWAY SCHOOL

Cornell University's Department of Agricultural Engineering has since 1951 conducted a research and extension program in local and rural roads. The program cooperates closely with other departments at Cornell, including the School of Civil Engineering, as well as with organized groups of town and county highway superintendents.

In 1956, an extension short course on "Location and Evaluation of Gravel Sources for Highway Use" was offered 12 times around New York state and reached about 200 highway officials. A short course on priorities for local road improvements will be offered this year.

The annual Highway School, a conference for local road officials, will be held on the Cornell campus July 8 through 10, 1957, and a registration of 300 is expected.

An Underground View of

RUSSIAN ENGINEERING EDUCATION

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This paper, presented as an unscheduled "sleeper" at the Annual Meeting, aroused widespread interest and enthusiasm as an unusual phenomenon —a presentation not to be taken over-seriously. Even in its present edited form, it should not be approached with heavy hand or literal mind.

While diplomatic relations between the United States and Russia may wax hot and cold with the passing of time, technological competition between the two countries continues at a steadily increasing gait, independent of the climate at the summit. Both countries have thousands of laboratories in which scientists and engineers are furiously theorizing, calculating, testing, and generally producing a host of new devices, techniques, and materials.

A major aspect of this USA-USSR technological competition has been particularly mystifying, and that is, how a country such as Russia, with a much lower standard of living and lower annual income, can continue to keep up the pace. Some people, whose thinking has undoubtedly been colored by emotion, characteristically dismiss Russian technological advancements as nothing but copies. Such an attitude is, however, reactionary and unrealistic. Russian accomplishments may in some instances lag those of the United States, but not by far. It is also noteworthy that the span of the lag decreases year by year.

One of the major contributing elements to Russia's accelerated scientific and technological activity is certainly their large and rapidly growing force of engineers. Regardless of *our* many fine engineering colleges, Russia annually graduates several times as many engineers. In 1955, for example, there were 63,000 new engineering graduates in Russia compared with some 23,000 in the United States.

The real impact of this situation becomes evident by comparing the figures for 1952, in which year both countries graduated the same number of engineers, approximately 30,000. While we might, given unlimited resources, provide physical plant to produce such an increase, the necessary qualified instructional staff is just not available in this country. The remarkable growth demonstrated by the Russians is rather mysterious—or was, until certain recent vistors to Russia managed a brief, illicit peek behind the sheepskin curtain.

Fresh Information

Although engineering education in Russia has already been the subject of countless papers and articles recently, the authors believe, with due respect to previous writers, that the information given here supersedes everything that has gone before. The authors feel, because of the tremendous importance to the national welfare

in general and to the teaching profession in particular, that this information should be released at the earliest possible date. With the sincere hope that our act of presenting this material will not bring down a shower of censure on our heads, we therefore shall set forth the incredible basis for Russia's ability to turn out so many engineers at such a low cost.

The Russian technique is, in a word, AUTOMATION. They have turned the engineers' favorite tool for production efficiency right back on its inventors, and are using automation to produce engineers. Briefly speaking, the Russians have established fully automatized engineering colleges in which nearly all operational, administrative, and teaching functions are performed by machines. As fantastic and grossly mechanistic as this may sound to the skeptics among us, the authors are of the opinion that we should at least review these revolutionary techniques before we arrive at any judgment. We shall therefore describe, in as great a detail as our present information permits, the methods used for automatized instruction in engineering. Suppose we accompany an aspiring young engineer as he makes application for entrance to the Engineering College of his choice.

Matriculation

The hopeful applicant is seen walking up the steps of a large, ultra-modern building. He is given his first taste of automation as the door swings open before him just as he is about to reach for it, while a voice emanating from no apparent source welcomes him to the college. Inside he first sees a number of young men and women seated at tables filling out forms and blanks.

Looking around for a clerk or receptionist to whom he may apply, his eye falls on a sign directing new applicants to a large, scientific-looking panel covered with lights, buttons, dials, and other impressive paraphernalia. A legend on the panel informs him that by pulling the lever to his right he will receive an application blank and a special pencil for filling it out.

He is to take a seat at one of the tables and, by checking appropriate items, answer all questions as to age, family, residence, fields of interest and presumed aptitudes, and so on. The application blank also includes personality, aptitude, and intelligence tests. He must complete filling out the entire blank, including the tests, within two hours or the application automatically becomes void. In combination with the fact that all application blanks contain different test questions, this is enough to prevent the applicants from helping one another.

Upon completing the questionnaire he returns it to a slot in the machine, which proceeds to whir and buzz for several seconds while lights on the panel blink and flash in confusing array. During this interval the machine is performing a fantastic number of operations: it is checking the accuracy of the applicant's personal data against previously filed information on all secondary school graduates; it grades and scores the aptitude, intelligence, and personality tests; and finally, the machine reviews all of the data on the applicant in the light of current quotas and makes the decision either to reject him temporarily or accept him and assign him to the proper curriculum.

Assuming that the applicant's test grades are satisfactory, that the per-

sonal data he supplied are accurate and free of exaggeration, and that the results of his personality and psychological tests show him capable of standing up under the training and life of an engineer, the machine regurgitates an identification card carrying, in addition to other pertinent data, finger prints and a photograph of the applicant taken while he was operating the buttons on the machine.

The applicant is then instructed by the machine to place his arm through a six inch diameter opening in the panel and grasp a bar which he will find there. When he does this, the machine quickly welds around his wrist a bracelet to which is attached a metal tag. As will be seen, the tag functions as a combination key and identification check for all intercourse between the student and the automated educational system.

With his identification card, the new freshman engineer receives a booklet of instructions explaining the operation of the college and setting forth rules of procedure to govern the student's activities during his stay there. He learns, for example, that all expenses, including tuition, clothing, room and board (a simple fare) are provided by the state.

He finds that a new freshman class is about to convene and that he is to move into dormitory space already assigned by the registration machine. His first class sessions will commence the following morning.

That evening he studies the rather voluminous instruction book and also begins reading the first assignments in the texts which he finds in his small room. At precisely 11:30 p.m. a voice states that the dormitory lights will be extinguished in thirty minutes and that he is to prepare for retiring.

At 7:00 the next morning he is awakened by the same voice and hurriedly washes and dresses for breakfast at 7:30. After breakfast he goes directly to his first class which, according to his schedule, meets in Room 201.

Upon reaching the entrance to the classroom, he inserts the metal tag on his wrist in a special slot in the turnstile-type door, thus allowing him to enter and at the same time recording his attendance. He seats himself in the auditorium-like room and a few minutes later senses a dimming of the lights in preparation for the first lecture.

In a three-dimensional color motion picture with stereophonic sound, one of the country's top-notch lecturers on the subject at hand (in this case, mathematics) proceeds to present introductory material. Every known trick of the motion picture art is used to make the lecture stimulating. Diagrams come alive in brilliant contrasting colors while pencils of light, accompanied by appropriate sound effects, trace out graphical relationships.

With all of the theatrical techniques available to him, the lecturer is able to set forth point after point of fundamental importance, so presented and augmented by visual and auditory stimuli that student interest is maintained constantly at a high pitch. It is interesting to note that the state of suspended animation, bordering on rigor mortis, which is so common in American college classrooms, is unheard of among Russian students.

The general efficiency of the filmed lectures is further enhanced by the fact that there is no time lost while the instructor is scribbling illegibly, or drawing crude, neolithic-looking diagrams on a poorly illuminated

blackboard; nor while he is trying to impress the class with stories of his industrial experience, nor while using the fact that he has a captive audience to expound his personal philosophies or tell his time-worn jokes.

The motion picture lecture on mathematics lasts forty-five minutes, after which the students have a question-and-answer period. Answers have been prepared in advance for every question that has ever been asked on the subject of the lecture. All the students needs to do is go through the list of questions at his desk, press the appropriate combination of buttons, and the lecturer will reappear on the screen.

The lecturer then answers the question by presenting the material in a different form than he had previously done in his principal lecture, and finishes by demonstrating the equivalence of the two procedures. The student has the privilege of asking as many questions as time permits before his next class meets.

The other classes are handled similarly—brilliant lecturers, presenting material organized and prepared to perfection and strikingly illustrated to maintain interest and maximize retention. It is easy to imagine what could be done along these lines with course after course—statics, dynamics, electrical engineering, thermodynamics, chemistry, and fluid mechanics, to mention only a few.

The question has been raised as to how the Russians manage to teach drafting, surveying, and the usual laboratory courses. While our information is not complete on this point, we understand that drafting as such, that is, the copying of numerous drawings from some text or workbook, has been relegated to the trade schools for the training of technicians, and the engineers are given only what is absolutely needed, i.e., instruction in the principles of orthographic projection and descriptive geometry by the usual motion picture lecture technique.

The laboratory courses have also been reduced to filmed lecture-demonstrations which have been found much more efficient than the American practice of allowing three-quarters of the students in our laboratory classes to indulge in several hours of horseplay while the remaining few try, under a severe handicap, to perform the experiment. Certain items of our information make it appear that the Russians are now developing a super-laboratory in which the student can gain practical experience while every manipulation, adjustment, or other critical operation he makes in performing the experiment is being continuously recorded, as well as the outcome of the experiment.

While discussing the motion picture lectures, we failed to mention that the same lecture is repeated five times a week. This allows a student who, upon returning to his room, finds himself a little shaky on some aspect of the assignment, to return and attend the lecture again. His second (or subsequent) attendance is recorded and filed for future reference in compiling grades, by the attendance machine when he inserts his identification tag in the door.

All students receive different homework assignments, and if a student needs help in completing the homework he can go to a hint booth where, with his identification tag, he can obtain hints for any or all of his problems. If, after receiving the first hint, he still has trouble, he can secure a second and stronger hint. Any hints

taken are, as usual, recorded for grading purposes. All homework is solved and submitted on special forms which are automatically graded and recorded.

When examination time arrives, the student goes to a small booth which he opens with his identification tag. As he closes the door, his examination papers are ejected onto the desk before him. As in the case of the homework assignments, he can get several orders of hints from a panel in the booth if he needs help, but his grade is reduced correspondingly for any help taken.

Like all other assignments, the examination is such that it can be answered by marking appropriate spots on the paper, and is therefore readily subject to machine grading. Numerically correct answers are required for each problem, no credit being given for incomplete or partially correct work.

Unlimited time is allowed for completion of the examination, but the grade received varies inversely with the time required. A special clock in the examination booth, like those for chess tournaments, indicates the rate at which the student's grade is being attenuated as he works to complete the examination, and thus gives him experience in working under pressure.

Having described a few details of the academic operation of the automated engineering colleges, we now turn to the administration. It should be evident that this system immediately displaces all of the instructional faculty and staff.

The few key men in each field who are featured in the filmed lectures are employed in industrial and military research and are kept available for revision and retakes of the films when necessary. Because all registration, paper grading, general bookkeeping, and student record functions are handled by computers, the nonacademic staff is also greatly reduced, to the point where only the dean's offices, buildings and grounds departments, and a crew of projectionists and technicians for maintaining the machines remains.

It has come to our attention, incidentally, that soon after the inauguration of this system it became evident that the deans and department heads were not performing any useful function, and that their secretaries were actually conducting the affairs of the college. All deans and department heads were therefore removed, and while it is not known for certain what happened to them, we understand that most of them were sent to the communal farms and given tasks more in keeping with their aptitudes.

Evidently the Russians have achieved a tremendous reduction in the cost per student by introducing automation into education. It is dubious, however, whether automatized education would be recommended for this country on the basis of economic gains alone. Considering the pay scales of the projectionists and technicians, in contrast to those of the teaching staff, it appears that little if any money would be saved. While our present teaching system is admittedly inefficient, it has the advantage of operating on cheap if not slave labor.

It is notable that—as in our domestic system—the buildings and grounds department has retained its position as the most powerful arm of the university. We are informed that the automatic education system has in fact been used as a means for still further enlarging their bailiwick.

The Russians are well aware of this situation, and are currently working on techniques for eliminating the buildings and grounds departments altogether. This too would be difficult to accomplish in the United States, because now that our relief organizations such as the WPA have been disbanded, we really have no means for absorbing such a large group of non-productive people into our society.

Some American educators who have been privately contacted have scoffed at the Russian system on the basis that motivation for the student is lacking. What, they ask, can replace the personal guidance and stimulation supplied by direct contact with the teacher? While there are, of course, exceptions, the American college teacher is apt to be a rather poor specimen from the viewpoint of stimulating the student.

The great bulk of college teachers are in their profession because, albeit the pay is low, the security is infinite and the responsibility is nil. Add to this the preoccupation of the typical engineering professor with writing his book, or carrying on his consulting practice, or trying to maintain peace at home while dallying with the secretary, and we may well wonder about his value as a source of enlightened stimulation to the student.

In contrast, the Russians have eliminated unscientific sentimentalities and traditions, such as the supposed stimulation of the student by the instructor, from the educational process, in favor of the strictly scientific approach. They have consulted the psychologists Pavlov and Obochevsky (the Russian Freud) to discover the strongest factors of motivation and have, of course, found them to be food and sex.

So, while grades are still assigned to students to determine their relative standing, the student is motivated to even greater accomplishment by suitable rewards for his efforts based on fundamental psychological data. Thus, many a delicious dish is enjoyed by the honor student.

Reassessment of accomplishment is made at carefully determined intervals to keep the student's interest at fever pitch. Incidentally, this system of rewards used as motivation is also responsible for the fact that there is a long waiting list of applicants for entrance to engineering schools.

Further advantages in avoiding personal contact between the teacher and student accrue from the elimination of personality as a factor in grades. The automatized education system produces grades which are a true index to the student's technological ability and are in no way related to how loudly he may laugh at an instructor's jokes. While not ignoring the importance of personality, the Russians believe in separating it from academic ability, and thus test the two characteristics independently.

The students receive report cards regularly from the grade-dispensing machine. These are supplemented by occasional commendatory or warning notes, according to the caliber of the work he has been doing. If a student's grades reach the point of unacceptability, he receives a notice from the grade-dispensing machine that he is being expelled.

Expulsion is a rather complicated process, but is essentially registration in reverse—including many more psychological and aptitude tests. The automatized education system re-analyzes, of course, the student's original registration data and all other data accumulated during his stay at the

school, in order to determine the reason for having misjudged him initially.

This information is stored in a central memory unit to assist in selecting and guiding future students. Expulsions are very rare in the automated educational system, though, because of the objectivity in the initial selection process and because of the stigma (with records) which follows the expelled student for the remainder of his life.

Graduation

For students who successfully complete the entire curriculum, there are, naturally, graduation exercises. An appropriate graduation speech is first presented (on film, of course) to the assembled degree candidates, who then solemnly march in single file past a large BESM machine, the Russian equivalent of our IBM, which, upon insertion of the identification tag, disgorges to each graduate a diploma in the form of a punched card, done up with a red ribbon. The card contains complete information on the grades, personality, and aptitude of the graduate, as well as his first industrial assignment and starting pay.

The End

Our description of the Russian system for rushin' engineering education is admittedly incomplete and may, in fact, be in error on some minor points as a result of the circuitous path through which we obtained our information. Although the tremendous importance of the subject matter may in part compensate for occasional inaccuracies, the authors respectfully ask the indulgence of the reader and trust that the information will be received in the same spirit in which it is offered.

NUCLEAR TESTS SYMPOSIUM

Nondestructive tests developed in the field of nuclear energy will be the subject of a symposium to be held at the Morrison Hotel, Chicago, Illinois, on April 16, 17, and 18. Information resulting from 15 years of research and development in nuclear testing applications will be discussed for the benefit of those interested in applying nondestructive test methods to industrial applications.

Recently declassified papers will be presented. They will be divided into three categories: reactor materials, including fuel, sheath or cladding, control and moderator material; completed fuel assemblies; and miscellaneous.

Papers will be presented in the morning and afternoon sessions each day, and in the evening of the first and second days there will be panel discussions in which the authors on the day's program will take part. The symposium is being sponsored jointly by the American Institute of Chemical Engineers, the American Nuclear Society, the American Society for Testing Materials, and the Society for Non-Destructive Testing.

GRAPHIC SCIENCE

Analysis—Synthesis—Communication

Sponsored by the Engineering Drawing Division
Editor: J. N. Arnold, Purdue University

THE GRAPHIC APPROACH TO ENGINEERING EDUCATION

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Presented at Fifth Engineering Drawing Summer School, Iowa State College, Ames, Iowa, June 26, 1956.

Teaching and learning are partners in the business of education. It is the teacher's job to help the student improve his ability to learn. The teacher knows that interest spurs effort, that an inquiring mind is the mainspring of the learning process. The successful teacher is continually appraising the effectiveness of his teaching. If a student fails to learn, is a cause his mental attitude toward his studies? Is it indifference, or lack of aptitude, or inability to grasp the meaning of study assignments?

In any case, the teacher must earn the student's confidence and full cooperation. It is not enough to dispense facts, explain theory, and answer questions. He cannot impart knowledge until the student has acquired the desire and ability to learn.

By showing a genuine interest in the student as an individual, however, the instructor can transmit some of his own enthusiasm and create initiative that will impel the student to taste the satisfaction of learning by his own effort. Therefore the student learns best when the teacher gets him started in the right direction, shows him how to use the tools that he will need, and then incites him to explore a particular field of knowledge for himself.

Graphic Approach

The freshman enters college with a healthy curiosity and an earnest desire to learn. In most cases, however, he does not know how to study. Too often he concentrates on memorizing facts and figures without understanding what he reads. Lacking guidance, he is apt to falter and stumble when the going is rough. Although he is eager to gain a full mental grasp of the subject, he often misses the central idea that clarifies its meaning.

Here the graphic approach offers him a helping hand when he needs it most. It awakens his mind by putting into lifelike pictures many things of which he has been only vaguely aware. While he studies, it translates his thoughts into pictures that tell their story clearly and completely. He welcomes this reliable guide to a better understanding of his study assignments.

The graphic approach is based on

the principle that the eye is the open door to the mind. Educators agree that most students learn faster and better from what they see in pictures and demonstrations than from the words they read in books or hear in lectures. Students prefer textbooks that contain many clarifying illustrations and they like teachers who explain things well by making effective use of visual aids to learning.

An enlightening picture spreads a message before student eyes, holds his attention, and makes it easy for him to understand its meaning. In this setting we can define the graphic approach to learning. It is a consistent plan to make students *picture-minded,* taking advantage of the strong appeal that pictures have for everyone, utilizing all forms of graphic expression, and helping the student develop the ability to form images in his mind in order to organize his thoughts and express his ideas.

Visual aids to learning include many forms of illustration that give the student indirect experience by portraying true-life situations. Models, mechanized demonstrations, motion pictures, television, film strips, projector slides, and photographs are effective visual aids, particularly when instruction deals with physical objects and relationships. Another class of visual aids includes drawings, sketches, maps, charts, graphs, and diagrams, that convey meaning clearly by the use of lines, areas, and symbols.

Sketches, graphs, and diagrams can be drawn quickly on the blackboard, using colored chalk for comparison and emphasis, and they can be readily adapted to suit the topic at hand. Blackboard sketches have the further advantage of permitting the teacher to explain the meaning of each aspect of the graph as he develops it, and the student can participate by asking questions and offering suggestions. When sketches and graphs are required as a part of homework assignments, they also give the student an opportunity to express his ideas in graphic form. This method increases the effectiveness of graphic aids.

Writing and Reading Graphically

For best results, however, the student must be taught how to write as well as read graphic language. As soon as he enters college, the engineering freshman starts a course in engineering drawing which teaches him the principles and methods of graphic expression, with emphasis on technical sketching and reading.

Although largely devoted to shape description and dimensioning of machine parts, many drawing courses now provide also an introduction to charts and graphs. Before he can draw a sketch or graph on paper, the student must see the corresponding picture in his mind. This exercise of mental vision puts his imagination to work and helps to develop his power of visualization. When he reaches out into a dim vista of words and numbers and tries to grasp the reality of their meaning, he learns how to translate his thoughts into meaningful lines on paper, so that the result will be unmistakably clear and effective. This requires accurate observation, exact thinking, and good judgment in the choice of graphic methods.

With continued practice the student becomes aware of the graphic nature of things. He welcomes the opportunity to express his ideas by means of sketches and graphs. Graphic expression fosters the growth of graphic insight. It clarifies his thinking, gives

direction and purpose to his studies, and makes learning more efficient.

Facility in the use of graphic methods is a necessary skill in teaching and learning mathematics and science, economics and engineering. The picture method of teaching and its helpful companion, the picture-sketching approach to learning, promise to lighten the task of education for the teacher and student alike.

In Other Subjects

It will be helpful to show how the graphic approach insures more effective teaching of mathematics, physics, mechanics, and other courses. Mathematics is clarified by a liberal use of graphs. Geometry, dealing with lines, planes, surfaces, and solids, requires continual reference to drawings in the textbook and on the blackboard. In teaching calculus, the concept of integration is made real to the student by drawing the curve of an equation and adding up the area between definite boundaries under the curve.

The graphic method of vectors has many useful applications in physics, mechanics, kinematics, and electrical engineering. In the study of these courses the mind pictures a force as a vector, a straight line with an arrow head on it, drawn parallel to the direction of the force. Its length represents the magnitude of the force and the arrowhead shows which way the force acts. Several forces may be combined in a vector diagram to determine their resultant, or to find the reactions, shear, and bending moment of a loaded beam. The Maxwell diagram, formed by combining several vector polygons, is used to determine the amount and kind of stress in each member of a framed structure.

In kinematics, vectors are indispensable for representing displacement, velocity, and acceleration, which form a solid base for the study of all mechanisms. Geologists draw isometric panel diagrams to show the relative position, extent, and slope of rock formations.

Economics depends upon charts and diagrams to give tangible meaning to trends, organization, and the flow of earning and spending. A pair of pie charts pictures the breakdown of the tax dollar to show where the money comes from and how it will be spent. The break-even chart reveals the critical point of profit or loss in the operation of a business venture. In many ways graphic methods prove their value by making difficult courses easier to understand.

Creative Process

Creative engineering begins with practical ideas in the engineer's mind. These ideas are the fruit of a fertile imagination whose roots are deep in the rich soil of experience. Fruitful ideas ripen in a favorable mental climate, and when they are combined with related ideas and properly developed, they grow into the master plan for the achievement visualized by the engineer. This thoughtful process requires originality, resourcefulness, and a constructive imagination.

Project engineers recommend the study of descriptive geometry as the best way to start developing these essential mental aptitudes. As the science of graphic expression, descriptive geometry puts into practice the engineer's method of thinking each problem through to a successful conclusion before drafting the correct solution according to plan. It gives the freshman valuable experience in

building with ideas the right kind of foundation for creative engineering.

The graphic approach provides a convenient outlet for inventive talent. When the habit of graphic thinking awakens the spark of genius in the mind of a gifted student, it releases bright, new ideas that are eager to escape on the wings of graphic expression. These fledgling ideas need to be tested for practical application on the drawing board and in the laboratory.

When strengthened by experience and adapted by ingenuity, such new ideas are cleverly developed into useful products. Modern invention is often a team-work project in which several creative minds work together and exchange ideas by means of technical sketches to ensure the most efficient and economical design. But creative engineering does not require that the student be endowed with native talent.

The continued use of graphic methods of thought and expression builds up in the mind a sense of perspective that is full of meaning in the domain of mental vision. This acquired aptitude of graphic insight widens the horizons of perception and it gives the student the ability to conceive many creative ideas that have useful engineering applications.

As Mental Development

To appreciate the educational value of the graphic approach we must consider its impact on the mental development of the student. It improves his learning ability by adding a new dimension to his thought pattern.

The study of engineering drawing and descriptive geometry requires visualization of problems in three dimensions, emphasizing the direction of sight and the importance of a favorable point of view. The third dimension sharpens the focus of mental vision to bring out details in bold relief. Illuminating dim corners of the mind, it transforms vague outlines into a bright perspective. But every picture has its blind side where hidden details may be overlooked.

Aware of this danger, the alert student weighs the merits of several view-points and selects the one that gives the picture its most meaningful aspect. Thus it is easy to form a mental image of a solid object or of a combination of lines and planes, but how can he visualize an abstract theorem? In study assignments he is confronted by definitions, principles, analysis of problems, methods of attack, rules, derivation of formulas, and results of experiments. How can he apply the graphic approach to improve his study habits? He should have a plan of study and a definite objective.

Elementary textbooks usually explain every detail of the subject with many helpful illustrations and appropriate examples to show how to put the principles into practice. Thus the author leads the student by the hand along the path of learning. But this support is gradually withdrawn as a more rigorous treatment is adopted in technical courses, so that the student must learn to walk alone across the gaps between guideposts suggested in the text.

Abstract vs. Concrete

When the student encounters an abstract theorem and tries to grasp its meaning, he usually endeavors to compare the new principle with some familiar concept in his past experience. This analogy often denotes similarity of relations instead of any

resemblance of the things themselves. It is important to discover the fundamental idea and make sure that the analogy holds at essential points. Correct perception requires insight. Here the ability to visualize every aspect of a situation and the mental habit of comparing properties, conditions, and results in a graphic frame of reference help the student translate abstract principles into tangible applications. For example, in the study of the electron microscope the rubber model is used to verify the theoretical tracing of electron paths through the electrostatic field between electrodes.

A thin membrane of surgical rubber is stretched over an electrode model, forming hill and valley features like a relief map, so that its height at any point represents the electric potential at that point. Then the horizontal projection of the path of a steel ball bearing rolling down the sloping surface of the membrane due to the force of gravity is identical with the path of an electron in the corresponding system. The top view of the electron path is recorded on a time-exposure photograph. The camera is directed downward at the shining steel ball as it rolls down the steepest slope of the model. This graphic analogy provides an accurate check on the mathematical approach to electron path plotting.

Design Facility

Many engineering graduates start their professional work in the research and development department of an industrial concern. As their duties are directly related to the design funtion of engineering, they are expected to have a good working knowledge of the engineering sciences as well as practical creative ability. They should be proficient in the effective use of all three languages of the engineer—English, mathematics, and graphics.

When words fail—and they are often inadequate—a clarifying sketch or enlightening chart will usually put the idea across immediately. The mathematics involved in modern research is often baffling in its complexity. In such cases a straightforward graphic analysis provides a valuable check on the mathematical solution and it spreads out before the eyes a clear picture of the entire problem, revealing aspects that may have been overlooked. Research and development projects involve teamwork assignments that demand a free exchange of ideas. Here ease in graphic expression is indispensable.

Graphics is not a spoken language, but the pencil speaks with an eloquent voice whenever it is used to make a quick sketch that everybody understands. Clever sketching ability is not a gift, but a habit. It is our duty as teachers to see that every engineering student makes effective sketching his constant habit of expression.

Engineering education is primarily an opportunity to develop special talents that the student can use effectively to give greater service in the world and thus to make his own life more successful. The benefits of education depend upon the effort that the student puts into it.

Let the teacher show him what to study and how to learn. After college studies are completed, self-education must continue for professional development. The forward-looking student of today needs the graphic approach to engineering education to prepare him for the dynamic challenge of unlimited engineering opportunities tomorrow.

NEW MEMBERS OF THE ASEE

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FABIAN, R. CRAIG, Supervisor, University Relations Department, Westinghouse Electric Corporation, East Pittsburgh, Pa. G. D. Lobingier, C. H. Ebert.

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BROWN, H. C., President, Texas Trade School, Dallas. H. A. Wood, C. H. Shumaker.

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KISIEL, CHESTER C., Instructor in Civil Engineering, University of Pittsburgh, Pittsburgh, Pennsylvania. J. P. Miller, R. Bonn.

KUSCHEL, WILLIAM G., Manager of Customer Engineering, IBM Corporation, 618 S. Michigan, Chicago 6, Illinois. T. J. Lafeber, O. I. Thompson.

LEFEUVRE, ALBERT R., Instructor in Mechanical Engineering, University of Toronto, Toronto 5, Ontario, Canada. L. E. Jones, D. G. Huber.

LEWIS, FLOYD F., JR., Head, Radio Engineering Department, Texas Trade School, Dallas, Texas. H. A. Wood, C. H. Shumaker.

MCENGE, WITHRO, Professor and Head, Industrial Education, Tuskegee Institute, Tuskegee, Alabama. J. D. Davis, Jr., William Allan. Divisional Interest: Administrator, Educational; Shope and Mechanic Arts, Technical Institute.

MARSHALL, MAURICE K., Assistant Professor of Mechanical Engineering, University of Kentucky, Lexington. M. Baker, R. E. Shaver.

NANIA, ANTHONY J., Instructor in English, Marquette University, Milwaukee, Wisconsin. R. J. Kipp, A. B. Drought. Divisional Interest: English, Humanistic-Social Studies.

OPPERMAN, DAVID R., Instructor in General Engineering, University of Illinois, Urbana. J. R. Tague, S. G. Hall. Divisional Interest: Engineering Drawing, General Engineering.

PAASCHE, OLAF, G., Associate Professor of Mechanical Enginering, Oregon State College, Corvallis. H. H. Paul, M. C. Sheely.

PEARCE, DAVID C., Assistant Instructor in Mechanical Engineering, Newark College of Engineering, Newark, New Jersey. G. B. Thom, J. H. Weinstein.

RAGLAND, DOUGLAS, Chief Petroleum Engineer, Humble Oil & Refining Company, Box 2180, Houston 1, Texas. J. R. Sims, J. E. Merwin. Divisional Interest: Petroleum Production, General Engineering.

REED, GEORGE A., Assistant Professor of Mechanical Engineering, Tuskegee Institute, Tuskegee, Alabama. J. D. Davis, Jr., William Allan.

RENNAT, HARRY O., Assistant Professor of Mechanical Engineering, Colorado A. & M. College, Fort Collins. R. D. LaRue, D. N. Zwiep.

REYNOLDS, WILLIAM E., President, The William E. Reynolds Company, Contractors and Engineers, Dayton, Ohio. W. L. Collins, J. O. Smith. Divisional Interest: Civil Engineering, History, Mathematics.

RICE, ROBERT B., Secretary, North Carolina Board of Registration, Raleigh. J. H. Lampe, J. H. Sams.

(*Continued on page 716*)

TEACHING POSITIONS AVAILABLE

ELECTRICAL ENGINEERING teaching positions will be available. Rank and salary commensurate with qualifications and experience. Opportunity for graduate study. Address inquiry to Dr. C. Froehlich, Department of Electrical Engineering, City College of New York, Convent Avenue and 139th Street, New York 31, New York.

ASSOCIATE AND ASSISTANT PROfessors for fields of advanced strength of materials, elasticity, dynamics, and fluid mechanics. Start February or September. Department of Applied Mechanics, University of Kansas, Lawrence, Kansas.

ASSISTANT AND ASSOCIATE PROfessors of Engineering needed. Able young Ph.D.'s interested in teaching and research in equal amounts. Well equipped and active professorial staff in thermodynamics and fluid mechanics is expanding to size comparable with internationally-known group in mechanics of solids. Excellent opportunity for development and advancement. Write to Professors J. Kestin, P. F. Maeder, or R. F. Probstein, or to D. C. Drucker, Chairman of Engineering, Brown University, Providence 12, Rhode Island.

ASSISTANT PROFESSOR OR ASSOciate to teach time study and methods courses at the graduate and undergraduate levels, plus the possibility of teaching other industrial engineering subjects. Salary for a nine month year contingent on education and experience; prefer man with advanced degree. Opportunity for graduate study, extra income for teaching evening courses, and for private consulting practice. Position available July 1, 1957. Resume of education and experience should be furnished in initial reply. Write to F. W. Winter, Department of Industrial and Management Engineering, Columbia University, New York 27, New York.

ASSISTANT AND ASSOCIATE PROfessors of engineering interested in teaching and research in equal amounts. Electronics and circuit men preferred to help complement group in electromagnetic theory. Excellent opportunity for development and advancement for qualified young Ph.D.'s. Write to Professor C. M. Angulo, R. D. Kodis, or E. T. Kornhauser or to Chairman of Engineering, Brown University, Providence 12, Rhode Island.

ELECTRICAL ENGINEERING AND Teaching Fellowships in large urban college. Part-time day teaching with tuition-free evening graduate work toward M.S. in Electrical Engineering. Summer employment available. Excellent opportunity for B.S. graduate who wants training for full-time engineering teaching. Salary increases and promotion on attainment of M.S. Also full-time teaching or part-time teaching plus part-time research available in ranks of Assistant Instructor through Assistant Professor. Annual salary increments. Evening teaching, graduate, and undergraduate, available with extra pay. Summer employment available. Apply to F. A. Russell, Acting Chairman, Department of Electrical Engineering, Newark College of Engineering, 365 High Street, Newark 2, New Jersey.

ELECTRICAL AND MECHANICAL Engineering staff openings at Ph.D. and M.S. levels. Salaries commensurate with qualifications. Apply to Dean of Engineering, Duke University, Durham, North Carolina.

GENERAL ENGINEERING INstructor and Assistant openings. B.S. engineering degree and good academic record required. Teaching or industrial experience desirable. Graduate study encouraged. Write to R. P. Hoelscher, 116 Transportation, University of Illinois, Urbana.

MECHANICAL ENGINEERING POSITION available for man interested in materials and mechanics or machine design; also position for electrical engineer. Will teach various fundamental courses. Assistant Professor rank, M.S. degree preferred. Apply to Dr. I. O. Addicott, Administrative Dean, Fresno State College, Fresno 26, California.

INCREASED MECHANICAL ENGINEERING faculty needed because of larger enrollment. Courses to be taught are thermodynamics, heat transfer, fluid mechanics, and laboratories. Persons should have some teaching and industrial experience. Salary and rank open depending upon degree and experience. Positions start September 15, 1957. Apply to the Dean of Engineering, Ohio Northern University, Ada, Ohio.

ELECTRICAL AND MECHANICAL Engineering positions open. Teaching assignments are Electric Power, Electronics, Mechanical Vibrations, Fluid Mechanics, and other Mechanical Engineering subjects. Salary depends upon qualifications. Excellent fringe benefits. M.S. in Electrical or Mechanical Engineering desired. Applicants with B.S. considered. Write to Earle M. Morecock, Chairman, Applied Science Division, Rochester Institute of Technology, Rochester, New York.

CIVIL, ELECTRICAL, AND MECHANICAL Engineering staff openings. Salary depends upon qualifications. Apply to the Dean of Engineering, Villanova University, Villanova, Pennsylvania.

CHEMICAL ENGINEERING FACULTY member needed. Rank and salary dependent upon qualifications. Send resume and recent photograph to the Chairman of Chemical Engineering and Chemistry Departments. Fenn College, Cleveland 15, Ohio.

CIVIL ENGINEERING INSTRUCTOR needed to begin in September, 1957. Apply to Professor E. W. Bowler, Chairman of Civil Engineering Department, University of New Hampshire, Durham.

CIVIL ENGINEERING DEPARTMENT Head position open. Ph.D. preferred but not necessary as experience in practice, research, teaching, and administration. Salary open. Appointment will be on an annual basis with one month vacation in summer. Ph.D. in Electrical or Mechanical Engineering needed to teach in and supervise an off-campus graduate program in a large urban community. Also need retired or part-time men who can teach high level courses in Electrical or Mechanical Engineering in this off-campus graduate program. Other openings in CE, ME, and EE. Apply to Dean John C. Park, College of Engineering, University of Arizona, Tucson, Arizona.

MACHINE DESIGN AND ENGINEERING Drawing Professor needed. Prefer middle age person with experience and M.S. degree or higher. Appointment for September 16, 1957. Write to Professor L. M. Sahag, Department of Engineering Drawing & Design, Alabama Polytechnic Institute, Auburn.

CIVIL ENGINEERING OR ENGINEERING Mechanics Associate and Assistant Professors and Instructors needed. M.S. degree desirable, but instructors working toward advanced degree will be considered. Salaries for nine months academic year, paid in ten installments, based upon experience and education. Start September, 1957. Applications for a position as Instructor in Engineering Drawing, Descriptive Geometry, and Surveying will also be considered. Write to Earl D. Dake, South Dakota School of Mines and Technology, Rapid City.

(*See also page 657.*)

REVISION OF THE ASEE CONSTITUTION

After several years of considering grass-roots suggestions, and with the benefits of detailed study by the Society Functions Committee, the Constitution and By-Laws Committee, at the direction of Council, undertook the complex task of phrasing and organizing specific statements of policy change. These were directed especially to modernizing the Society's structure, to re-defining classes of members, to speeding its processes and actions in terms of meeting current demands, and to bringing it into line with present practices of professional organizations.

Results of the Committee's deliberations were embodied in two major reports to the General Council, presented at the 1955 Annual Meeting at The Pennsylvania State University and the 1956 Annual Meeting at Iowa State College. These proposals were accepted by the General Council during the fall meeting (October 27, 1956) at Detroit. As specified in the procedure for amending the Constitution, endorsement was also voted by the ECAC through a letter ballot reported on January 17, 1957, and by the ECRC at its Executive Committee meeting in Chicago on February 28, 1957.

With these endorsements, the amended Constitution is now submitted to members of the Society for referendum vote. This page, and its reverse, constitute a tear-out ballot. Please remove this sheet, record your vote, and return it to the Secretary of the Society, preferably by June 1, 1957. If response is prompt, it is hoped that the final Society action can be announced at the Annual Meeting at Ithaca, June 17–21.

Ballot on Revision of Constitution
The American Society for Enginering Education

_____
date

Please return to W. Leighton Collins, Secretary, ASEE,
University of Illinois, Urbana, before June 10, 1957.

I approve all the changes as printed following this ballot: ( )

I approve and disapprove specific sections, as indicated below: ( )

If complete approval is given, the blocks below *need not* be filled in.)

Detailed Changes, by Articles and Sections	*Approve*	*Disapprove*
Article II–Membership		
Section 2 (Adds "Life" category of members.)	( )	( )
Section 3 (Provides for approval of new members by Executive Board rather than by Council.)	( )	( )
Section 6 (Formerly Sec. 3; provides for nomination of honorary members as individuals.)	( )	( )
Section 7 (Provides an "industrial" class of institutional members.)	( )	( )
Section 11 (Executive Board empowered to classify and elect industrial institutional members.)	( )	( )

Detailed Changes, by Articles and Sections	*Approve*	*Disapprove*
Article III—Organization		
Section 2 (Broadened to include present "General" or "Activity" Divisions.)	( )	( )
Article IV—Officers		
(Adds two Vice Presidents, one for general and Regional Activities (east and west), one for general Divisions and Committees.)	( )	( )
Article V—Executive Board		
Section 1 (Defines present functions of Executive Board.)	( )	( )
Article VI—General Council		
Section 1 (Adds secretaries of ECAC and ECRC to General Council membership.)	( )	( )
Article IX—Title Change		
(Adds "committees" to title.)	( )	( )
Section 4 (Re-numbered to "3.")	( )	( )
Section 5 (Re-numbered to "4.")	( )	( )
Article X—Election of Officers		
Section 1 (Provides for election of officers by mail ballot.)	( )	( )
Section 3 (Establishes election procedure.)	( )	( )
Article XI—Dues		
Section 5 (Reduces arrearage payment for membership renewal.)	( )	( )
Section VI (Exempts honorary members from dues.)	( )	( )
Article XIII—Publications		
Section 2 (Defines Society's rights to papers.)	( )	( )
By-Laws		
Seventh (Designates to whom standing committees are responsible.)	( )	( )
Eighth (Provides for Editor, and broadens representation on Publications Committee.)	( )	( )
Ninth (Establishes Awards Committee.)	( )	( )
Tenth (Simplifies amending By-laws.)	( )	( )

CONSTITUTION AND BY-LAWS

(Effective July 1, 1957)

American Society for Engineering Education

FORMERLY THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

Printed below is the ASEE Constitution, *including proposed changes*, as it will read if all revisions are adopted. Both past and proposed versions were printed in the JOURNAL (September, 1956, pages 48–49 and December, 1956, pages 368–375), and can be referred to there. The old text, as it has been in force since the spring of 1954, is printed in full in the Yearbook (February, 1957, pages 519–531).

Article I—Name and Objects

Section 1. The name of this organization shall be the American Society for Engineering Education.

Section 2. The Society shall be a continuation of the Society for the Promotion of Engineering Education and its organization and purpose shall be expanded so as to include those of the Engineering College Research Association.

Section 3. The purpose of this Society shall be the advancement of education in all its functions which pertain to engineering and allied branches of science and technology, including the processes of teaching and learning, research, extension services, and public relations. The Society shall serve its members as a common agency of stimulation and guidance in: (*a*) the formulation of the general goals and responsibilities of engineering education for the service of individuals and the advancement of general welfare, (*b*) the adjustment of curricula and educational processes to changing conditions; (*c*) the development of effective teachers and administrators; (*d*) the improvement of instructional materials and methods, of personnel practices, and of administrative usages; (*e*) the enhancement of professional ideals and standards; (*f*) the fostering of research as a function collateral to teaching; (*g*) the coordination of institutional aims and programs, both among schools and colleges and in their joint relations with professional, educational, and public bodies; and (*h*) the cultivation of a fraternal spirit among teachers, administrators, investigators, practitioners, and industrialists.

Article II—Membership

Section 1. Membership in the Society shall be of two general classes, Individual and Institutional.

Section 2. Individual membership shall be of three classes, Active, Life, and Honorary. It shall comprise those persons who occupy or have occupied responsible positions in engineering instruction, research, or practice, or other persons interested in engineering education.

Adds "Life" Category of members.

Section 3. The name of each candidate for active individual membership shall be proposed in writing to the Secretary by two members of whom the candidate is personally known. The proposal shall state the qualifications on which it is based. An affirmative letter ballot of three-fourths of those members of the Executive Board whose votes reach the Secretary within one month from the time of sending out the name of the candidate shall elect.

Approval of members by Executive Board rather than by General Council.

Section 4. A member in good standing may become a life member, exempt from all future payments for dues, by a single payment of an amount equal to twenty times the annual dues for members. Such payments received by the Society shall be placed in a separate fund known as the Life Membership Fund. The interest earned on this fund shall be used as current income.

Section 5. An individual member who has been in good standing for twenty-five (25) years or more, who has reached the age of sixty-five (65) years, and who has retired from active professional life, may, upon written request, be designated as a life member by vote of the General Council, and shall thereafter be exempt from payment of dues.

Section 6. Honorary members may be chosen from among those who have rendered eminent service to mankind in engineering education or other engineering fields. Nomination of such candidates may be made by any member of the Society to the Committee on Honorary Membership. The Committee on Honorary Membership will in turn recommend to the General Council candidates for honorary membership.

Formerly Sec. 3; provides for nomination of honorary members by individuals.

Election shall be by a favorable vote of at least three-fourths of the members of the General Council in a letter ballot to be taken by the secretary. Councilors not heard from within one month from the date of mailing the ballots will be counted in favor of the candidate.

Honorary members shall enjoy all the privileges of the Society, and shall not be required to pay any fees or dues.

Election to honorary membership shall be limited in any administrative year to not more than two candidates.

Section 7. Institutional members shall be of four classes: Active, Affiliate, Associate, and Industrial. Active members shall be institutions which are eligible to participate in either or both of the institutional membership Councils. Affiliate members shall be other educational institutions engaged in technical instruction which have one or more curricula accredited by Engineers' Council for Professional Development or which are accredited by a major regional educational association. Associate members shall be professional organizations of engineers and research institutions. Industrial members shall be industrial organizations which have a major interest in engineering education.

Provides an "Industrial" class of institutional members.

Section 8. Active member institutions shall be only those offering curricula leading to baccalaureate or higher degree in engineering and having one or more curricula accredited as such by Engineers' Council for Professional Development, or if not within its jurisdiction must have one or more engineering curricula whose standards as judged by a competent accrediting agency are not lower than those of that Council. In the absence of any such accrediting agency the Executive Board of the Society shall have the power to judge of the equivalence of standards.

Section 9. All institutions which meet the conditions described in section 8 shall be eligible to participate as voting members in the Engineering College Administrative Council. To be eligible for voting participation in the Engineering College Research Council it is further required that the institution's research organization or activity shall have existed for at least three (3) years and shall have expended for engineering research during the three (3) fiscal years next preceding the date of its admission to the Council not less than that sum prescribed in the by-laws of the Engineering College Research Council.

Section 10. An institution may be proposed for membership by an official representative of any member institution who is familiar with the work of the institution proposed; or application for admission may be made directly by a responsible officer of the institution concerned. In either case the proposal or application shall be made in writing, addressed to the Secretary of the Society, and shall indicate the grade of membership applied for and the Council or Councils in which it wishes to participate.

Section 11. The Executive Board shall determine the eligibility of the applicant for membership of any class in the Society. The Executive Board shall have the power to elect Affiliate, Associate, and Industrial members of the Society by letter ballot, but shall refer applications for Active membership to the Executive Committee of each of the Councils in which the applicant desires to participate, each such Executive Committee being empowered to admit the applicant to the Council which it represents. All elections shall require a two-thirds favorable vote of the ballots cast. Institutions thus elected to membership in either or both of the institutional Councils thereby become Active institutional members of the Society.

Executive Board empowered to classify and elect industrial institutional members. (Conforms with Sec. 7, Art. II.)

Article III—Organization

Section 1. The means to ends specified in Article I, section 3, shall include the establishment of subordinate units of organization as needed to serve local, regional, departmental, or functional interests, the holding of meetings, conferences, and special schools, the setting up of agencies for educational inquiry, research, or planning, and the publication of papers, reports, researches, communications, and other significant materials concerned with engineering education.

Section 2. The Society shall be an organization of individual and institutional members and shall operate in two coordinate areas of activity corresponding to the respective interests of these groups. Its general activities shall be administered by an Executive Board (see Article V). The activities of its individual members shall be conducted under a General Council (see Article VI) and the activities of its institutional members through an Engineering College Research Council (see Article VII), and an Engineering College Administrative Council (see Article VIII).

The individual members of the Society shall further be organized in groups to function as (a) sections in specified territories; (b) branches formed by members of single institutions and (c) divisions with important subjects of instruction, research, or activity related to engineering education, under provisions as hereinafter set forth.

Broadened to include "general" or "activity" Divisions.

Article IV—Officers

There shall be a President, who shall be the executive officer of the Society and who shall hold office for one year. There shall be six Vice Presidents, each to hold office for two years as follows: in connection with individual memberships, two Vice Presidents responsible for General and Regional Activities, one in the Eastern part of the United States and one in the Western part, as designated by the Executive Board, to be elected in alternate years: a Vice President for instructional Divisions and Committees and a Vice President for General Divisions and Committees to be elected in alternate years. In connection with institutional memberships, there shall be a Vice President for the Engineering College Research Council and a Vice President responsible for the Engineering College Administrative Council, to be elected in alternate years. There shall be a secretary, to be appointed annually by a committee consisting of the President and all Vice Presidents; and a Treasurer, to be elected annually. In case of vacancy in the office of the President, the senior Vice President for General and Regional Activities shall succeed. In case of a vacancy in the office of Vice President for General and Regional Activities, the senior Vice President for Instructional Divisions shall succeed.

Adds two Vice Presidents to deal with individual members.

Article V—Executive Board

Section 1. The Executive Board of the Society shall consist of the President, the six Vice Presidents, the Secretary, and the Treasurer. Its function shall be to coordinate the activities of the Society. Its actions shall be final as to (a) approval of budgets, (b) authorization of publications, (c) conventions, (d) appointment of officers to fill emergency vacancies, (e) determination of eligibility of institutional members, and (f) actions of the Society in relation to other organizations. The Executive Board is responsible for the general supervision and control of all financial matters in which the name of the Society is used. In all other matters, however, the Executive Board is advisory to the General Council, the Engineering College Research Council, and the Engineering College Administrative Council.

Defines present functions of Executive Board.

Section 2. The procedure in (*d*) filling emergency vacancies shall be as follows: excepting the Secretary, whose appointment is otherwise provided herein, the Executive Board shall make the appointment on recommendation of the President; provided, however, that, in case of vacancy in the office of a Vice President associated with the institutional membership, the President shall transmit to the Executive Board the recommendation of the Executive Committee concerned. The term of emergency appointments shall be until a successor is regularly elected.

Section 3. In case of a national emergency during which it is impossible for the Society to hold a regular meeting, the Executive Board may take any action on behalf of the Society that it deems necessary and advisable; provided, however, that such action shall be reported to the Society at its first regular meeting thereafter.

Section 4. Each Council of the Society shall report all of its actions to the Executive Board and shall not take an action affecting the interests of another Council until such proposed action has been cosidered by the

Executive Board; provided, however, that in cases where the time element is too critical to permit deliberation by the Executive Board, a Council may, on its own responsibility, take emergency action within its own domain, or if it so authorizes, its Executive Committee may take such action; or provided further that a Council, or its Executive Committee if so authorized, may take such action jointly with another Council where joint interests are involved.

Article VI—General Council

Section 1. The General Council of the Society shall consist of the President, who shall be chairman, the six Vice Presidents, the Secretary, the Treasurer, the three Junior Past Presidents, the secretaries of the Enginering College Research Council and the Engineering College Administrative Council, and a representative of every Division and Section elected by the body concerned for a term of two years according to a plan of rotation in which one half of such representatives will be chosen each year.

Adds Secretaries of ECRC and ECAC to General Council membership.

Section 2. Any individual member of the Society shall be eligible for election as such a representative on the General Council.

Section 3. Incumbent elective officers and members of the Council shall continue in office for a period of ten (10) days after the date of the annual meeting or in the event that no annual meeting is held, until ten (10) days after their successors shall have been elected.

Section 4. The actions of the General Council shall be final on all matters concerning the General and Regional Activities and the Instructional Divisions, excepting those herein delegated to the Executive Board.

Section 5. The General Council shall determine its own By-laws which shall conform to the Constitution and By-laws of the Society.

Article VII—Engineering College Research Council

Section 1. There shall be an Engineering College Research Council whose purpose shall be to assist in developing the research facilities of engineering colleges (*a*) to further advance study in colleges of engineering and to develop and coordinate industrial and scientific research; (*b*) to undertake research designed to promote engineering advancement and economic adjustment in industry, public works, public health, the conservation and development of natural resources, and similar activities; (*c*) to cooperate with other associations and government agencies in the prosecution and promotion of research and to collaborate with them to prevent duplication of effort and achieve maximum utilization, coordination, and development of engineering and scientific research facilities; and (*d*) to publish periodic research reports, studies, papers, and investigations of significant value to engineering colleges and cooperating research agencies.

Section 2. Its membership shall consist of institutions complying with the By-laws of the Research Council. There shall be Active (voting) and Associate (non-voting) membership. Each membership shall be entitled to one or more representatives designated by the proper officer of each member institution. Each Active Institutional membership shall

have but one vote. All Institutional memberships shall be admitted by the Research Council.

Section 3. There shall be an Executive Committee of, and constituted by, the Engineering College Research Council; provided, however, that the Vice President of the Society associated with this Council shall be Chairman of the Council; and the President, Treasurer, and Secretary of the Society shall be ex officio advisory members without vote; and its powers shall be those delegated to it by this Council.

Section 4. The Engineering College Research Council shall determine its own By-laws which shall conform to the Constitution and By-laws of the Society.

Article VIII—Engineering College Administrative Council

Section 1. There shall be an Engineering College Administrative Council whose purpose shall be (*a*) to relate the engineering colleges to public welfare by close cooperation with the agencies of the Government; (*b*) to bring about cooperation among engineering colleges in the interest of the engineering profession, industry, and the public at large; (*c*) to bring about cooperation between the engineering colleges of this country and those of other lands; (*d*) to cooperate with engineering societies, trade organizations, and commercial groups in the interest of engineering education; (*e*) to act as an instrument of inquiry into problems which contribute to effective administration of engineering colleges; (*f*) to make the public conscious of the value of engineering education as a preparation for service to society in a technologic civilization.

Section 2. Its membership shall include one duly appointed representative of each such Active Institutional Members and Associate Institutional Members (non-voting) as are admitted to the Engineering College Administrative Council.

Section 3. There shall be an Executive Committee of, and constituted by, the Engineering College Administrative Council; provided, however, that the Vice President of the Society associated with this Council shall be Chairman of the Council; and the President, Treasurer, and Secretary of the Society shall be ex officio advisory members without vote; and its powers shall be those delegated to it by this Council.

Section 4. The Engineering College Administrative Council shall determine its own By-laws which shall conform to the Constitution and By-laws of the Society.

Article IX—Sections, Branches, Divisions, and Committees

Adds "Committees" to title.

Section 1. A section of the Society may be formed by members of the Society in two or more institutions and for all members within a territory prescribed by the General Council. A Section may be formed by a temporary organization which shall become a duly authorized section of the Society upon the approval of the General Council. Sections may determine their own form of organization, but shall operate in conformity with the Constitution and the By-laws of the Society and shall make a report of their proceedings to the Secretary of the Society. Sections shall be self-sustaining.

Section 2. A Branch may be formed by members of the Society in any one or more institution(s) by a temporary organization, which shall become a duly authorized Branch of the Society upon approval by the Executive Board. Branches may determine their own form of organization, but shall operate in conformity with the Constitution and the By-laws of the Society and shall make a report of their proceedings to the Secretary of the Society. Branches shall be self-sustaining.

Branches may cooperate with, or be a part of, other organizations having the same general purposes as this Society. The general purpose of Branches is to extend the interest in, and the discussion of, questions relating to the teaching of engineering students and to bring to the Society at large, through its publications, the activities in all institutions that will be serviceable to the members of the Society.

Section 3. The General Council may establish Divisions of the Society in areas of instructional responsibility generally existing in engineering colleges, e.g., mathematics, electrical engineering, etc., and in fields of major interest within the Society not directly related to instruction. *Re-numbered.*

Section 4. The Executive Board, the General Council, the Engineering College Research Council, and the Engineering College Administrative Council may establish committees in their respective domains as prescribed in the By-laws. *Re-numbered.*

Article X—Election of Officers

Section 1. The President, Treasurer, and four Vice Presidents, who must be members of the Society, shall be elected by mail ballot of the individual membership. The President and Treasurer shall be elected annually. The two Vice Presidents for General and Regional Activities shall be elected in alternate years. The Vice President for Instructional Division and Committee Activities and the Vice President for General Divisions and Committees shall be elected in alternate years. The two Vice Presidents associated with institutional membership shall be elected at the annual meeting of the Society in alternate years for respective terms of two years by their respective councils. *Provides for election of officers by mail ballot.*

Section 2. There shall be a Nominating Committee consisting of the three Junior Past Presidents, senior member to be chairman, and those General Council members elected by the Sections and Divisions whose terms expire in the year in which the annual meeting is held.

Section 3. By means of a form furnished at the beginning of each academic year, an opportunity shall be given to individual members of the Society to submit names of persons to be considered for nomination. These names, on the forms provided, shall be sent to the Secretary of the Society not less than thirty (30) days prior to the fall meeting of the General Council. The Secretary shall submit the suggested names to all members of the Nominating Committee. At the time of the fall meeting of the General Council the Nominating Committee shall select candidates whose names shall be made available to the entire membership in December or January. After the publication of the nominees proposed by the Nominating Committee, other nominations may be made by petition of 50 signatures of members of the Society in good standing. Each nominee must have indicated his willingness to serve if elected before his name *Establishes election procedures.*

can be placed on the ballot. In February or March ballots giving the names of all candidates will be provided. Ballots received by the Secretary by March 31 shall determine the election of the officers as of April 1. Their terms of office shall begin ten days after the date of the annual meeting.

Article XI—Dues

Section 1. There shall be no admission fee.

Section 2. The annual dues shall be as stated in the By-laws of the Society, and any change in the dues of individual membership shall be determined by letter ballot of such membership.

Section. 3. A member elected prior to February 1 in any fiscal year shall pay the full dues of that year; if elected after February 1, he shall pay half the dues of that year.

Section 4. Dues are payable in advance at the beginning of each fiscal year and shall be considered in arrears if not paid by the end of the fiscal year for which they are assessed. Dues of new members are payable at the time of election and shall be considered in arrears if not paid by the end of the fiscal year within which they are elected.

Section 5. Members in arrears one year shall be retained on the roll of the Society. Members who are in arrears two years, and who have been duly notified by the secretary shall be dropped from the roll of the Society. Anyone who has been dropped from membership for non-payment of dues may renew his membership by applying in the usual way and paying the arrearage in dues for the year during which he received the JOURNAL OF ENGINEERING EDUCATION.

Reduces arrearage payments for membership renewals.

Section 6. Honorary members shall be exempt from payment of dues.

Added to comply with Sec. 6 of Art. II.

Article XII—Meetings

There shall be at least one annual meeting at such time and place as the Society at the preceding meeting, or the Executive Board, if the Society does not act, may determine. The Executive Board shall authorize the time and place of meetings held under the auspices of Divisions and Committees excepting those held at national conventions of the Society.

Article XIII—Publications

Section 1. The Executive Board shall authorize all official publications of the Society and shall also prescribe the rights of the several grades of members in connection with these publications.

Section 2. Papers and discussions presented before Sectional, Branch, Divisional, and Annual meetings or submitted in contests in Section, Branches, Divisions, and the Society at large shall be the property of the Society and may be published as Society proceedings if authorized by the Publications Committee. The Secretary shall have authority to waive property rights of the Society or to grant permission to publish such papers and discussions elsewhere on condition that the Society receives proper credit.

Defines Society's rights to papers presented or submitted for Society purposes.

Article XIV—Amendments

This constitution may be amended by a favorable vote of the individual members of the Society, the proposed amendment being approved if at least two-thirds of the ballots returned within thirty (30) days after they are mailed out are favorable; and provided further (*a*) that the proposed amendment has first been voted upon by each of the three Councils of the Society and (*b*) that the results of such votes be recorded in the notice sent out to the membership with the ballots.

BY-LAWS OF THE SOCIETY

First. The Executive Board shall arrange for the annual meeting and prepare a program for it.

Second. Each Vice President shall submit a proposed budget for the activities for which he is responsible, to the Executive Board through the Secretary, who shall incorporate it with the General Budget so that the total proposed budget may be submitted to the Executive Board before May 1.

Third. Disbursements from the funds of the Society shall be made by the Treasurer in accordance with the approved budget or a direct appropriation authorized by the Executive Board for a special purpose, and upon vouchers signed by the Secretary of the Society.

Fourth. Within the ceiling limits for dues hereby established, the dues of members may be adjusted annually by the General Council at the same Council Meeting at which the annual budget is considered. The dues shall be so adjusted within the ceiling limits hereby established that over a reasonable period of years the Society shall not incur a deficit that in the opinion of the General Council might endanger continuity of operations.

The ceiling on dues shall be $7.00 per year for those who have not reached their 36th birthday at the beginning of the fiscal year (July 1) and $10.00 per year for all other individual members. Except for the first year after the adoption of this By-Law, the increase in dues approved at any one time shall not exceed $1.00 for individual members.

During the first year after adoption of this By-Law, the dues for individual members will be $6.00 for members who have not reached their 36th birthday by July 1, 1954, and $8.00 for all other members.

The annual dues of institutional members will be as follows:

1. Active Members
    a. Participating in both Institutional Councils, $50.00.
    b. participating in only one Institutional Council, $35.00
2. Associate Members, $50.00
3. Affiliate Members, $25.00

Fifth. The fiscal year of the Society shall be July 1 to June 30.

Sixth. The Secretary of the Society shall be secretary of the Executive Board.

Seventh. Committees reporting to either Institutional Council shall be authorized by the Executive Committee concerned and be appointed by the Vice President concerned. Committees of Sections, Branches, or Divisions shall be authorized by the body concerned and be appointed by

the chairman of the body concerned. The ASEE Awards Committees (both for specific Society prizes and for coordination of award activities), the Membership Committees, the Financial Policy Committee, the Publications Committee, the Public Relations Committee, the Annual Meeting Committee, and the Constitution and By-Laws Committee are appointed by the President and are responsible to the Executive Board. Other standing committees and committees for special projects authorized by the Executive Board and General Council shall be appointed by the President with staff responsibility designated to the appropriate Vice President.

Designates to whom standing committees are responsible.

Eighth. There shall be a Publication Committee consisting of the President, the junior Past President, the Editor (appointed by the Executive Board), the Chairman of the English Division (ex-officio), the Secretaries of Engineering College Administrative Council and Engineering College Research Council, and the Secretary of the Society, who shall be chairman. It shall be responsible to the Executive Board for the general administration of all official publications of the Society.

Provides for Editor and broadens representation on Publications Committee.

The Editor shall be in direct charge of the JOURNAL OF ENGINEERING EDUCATION. Publications authorized by the Engineering College Research Council and the Engineering College Administrative Council shall be edited and published in accordance with plans of procedure recommended by these respective Councils and approved by the Executive Board.

The selling price of all publications shall be determined by the Executive Board on recommendation of the Publications Committee.

All income from publications shall be classified as income of the Society applicable to the annual budget of the Society.

Ninth. The Awards Policy Committee is responsible for establishing and coordinating policy, including procedures for presentations, with respect to awards presented in the name of the society or a constituent part of the society.

Establishes policy committee for coordination of Society awards.

Tenth. These By-laws, excepting as they relate to dues of individual members, may be amended by a two-thirds vote of the members present at any regular meeting of the Society, provided that all individual and institutional members have been notified of the proposed amendment by notices published in the JOURNAL at least thirty (30) days prior to the said regular meeting at which action is to be taken, and provided further that the proposed amendment has first been voted upon by the General Council and the results of such vote recorded in the notice sent out for the meeting at which the proposed amendment is to be acted upon.

Simplifies amending By-Laws.

The dues of individual members may be changed only by a majority vote received by letter ballot of individual members.

Clarifies vote on dues changes.

EMPATHY AND ENTROPY (Continued from page 661)

ergy) at the expense of discipline, meaning, or signal, and effective production of intelligence, we will realize that an empathetic approach to the communication or teaching problem will anticipate and provide for redundancy, repetition, and restatement of the message in different terms until compatibility has been established with the receiver and the unexpectedness-shock of the message has been overcome.

The teacher, of course, must use all of Warren Weaver's levels of communication, especially his last, the highest and most complex one. The technical worker in the electronics, computer, or automation fields eases his problem by saying that he is simply not interested in meaning (though *somebody* who programs the operation must finally be!). The teacher, however, must not only be concerned with accurate and effective *control* (as for an automated machine tool) in the transmission of information, but must also operate at much higher levels in terms of attitudes, motivation, ethics, creative thought, efficient planning, and constructive, professional undertaking of individual responsibility.

In these latter areas empathy becomes the final and significant term, as it triumphs over the negative entropy. There is, then, no more important attribute for a teacher, young or old, to develop than the ability to understand and appreciate instinctively and constantly how his students think and feel. This does *not* mean that he should *yield* to their weaknesses; certainly it *does* mean that he should not use his comprehension to mislead or to take advantage of them. That is the measure of his true empathy, to participate only for the purpose of ennobling and assisting. Like Mark Hopkins, he must so conduct himself as a teacher not only so that the student's hero-worship is justified, but so that the student can rise above mere admiration to creative achievements of his own!

In thus creating by a combination of empathy and scientific knowledge the means both of continuing and transmitting knowledge, and of overcoming the inherent tendencies to confusion and wastage, the teacher is realizing his proper function. Perhaps we can now add a term to Eddington's group, placing empathy above but in illuminating relation to entropy. At any rate, I leave you to further exploration of this fascinating field, with all its implications for success in one of the most rewarding of careers!

NEW MEMBERS (Continued from page 700.)

ROSTRON, CHARLES R., Assistant Professor of Civil Engineering, Louisiana Polytechnic Institute, Ruston. J. Painter, A. C. Thigpen.

SHIVE, JOHN N., Department of Education and Training, Bell Telephone Laboratories, Inc., Murray Hill, New Jersey. S. B. Ingram, R. A. Deller.

SLIEPCEVICH, CEDOMIR M., Professor and Chairman of Chemical Engineering, University of Oklahoma, Norman. R. L. Huntington, W. H. Carson. Divisional Interest: Associate Dean, Chemical Engineering.

SMITH, WESLEY W., Associate Professor of Mechanical Engineering, Oregon State College, Corvallis. J. L. Gray, P. A. Wanless.

TRAMMELL, GUY R., Head of Electrical Department, Tuskegee Institute, Tuskegee, Alabama. J. D. Davis, Jr., William Allan.

ULDRICK, JOHN P., Instructor in Engineering, Clemson College, Clemson, South Carolina. J. C. Cook, Jr., J. L. Edwards.

WILCOX, L. R., Associate Professor of Mathematics, Illinois Institute of Technology, Chicago, Illinois. H. Reingold, R. G. Owens. Divisional Interest: Electrical Engineering, Mathematics.

WILSON, CHARLES E., JR., Assistant Instructor in Mechanical Engineering, Newark College of Engineering, Newark, New Jersey. G. B. Thom, J. H. Weinstein.

149 new members
485 previously added
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634 new members

THE SCIENCE OF ENGINEERING MATERIALS

"The Impact of Solid State Science on Engineering Materials" was the subject of two conferences sponsored by ASEE in the spring of 1954, in cooperation with the National Science Foundation, the University of Illinois, and the Carnegie Institute of Technology. The closed conference at Illinois recommended that engineering curricula include formal course work in modern physics and the theory of the solid state, and planned the open conference program at Carnegie.

The papers presented at Carnegie have been edited by Dr. J. E. Goldman, Manager of the Physics Department of the Scientific Laboratory of the Ford Motor Company and formerly with the Carnegie Institute of Technology. The proceedings are now being published as a book, *The Science of Engineering Materials*. Containing about 540 pages and 240 illustrations, the volume will be ready in May at an estimated price of about $9.75. All orders should be sent directly to John Wiley and Sons, Inc., the publishers.